IMPERIAL INSTITUTE

OF THE

UNITED KINGDOM, THE COLONIES AND INDIA.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT.

PARTS I TO V.

FIBRES; GUMS AND RESINS; FOODSTUFFS; RUBBER AND GUTTA PERCHA; OIL-SEEDS, OILS, FATS AND WAXES.

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COLONIAL REPORTS—MISCELLANEOUS.

No. 58.

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Edited by the DIRECTOR.

I.—FIBRES.

Presented to both Houses of Parliament by Command of His Majesty.
May, 1909.

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SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

I.—FIBRES.

INTRODUCTION.

In 1903 a volume of "Technical Reports and Scientific Papers" was issued by the Imperial Institute, which included the principal reports on those raw materials and commercial products which had been made the subject of investigation in the Scientific and Technical Department of the Imperial Institute, chiefly at the instance of the Indian and Colonial Governments or of British representatives abroad in the interests of British trade and manufactures.

This volume has been in considerable demand, and it has therefore been decided to publish a selection of the similar reports which have been made since it was issued. The work of the Imperial Institute has, however, grown to such large dimensions in recent years that it is not possible to include in a single volume even a selection of the principal reports on all the various subjects which have been investigated.

The information will therefore be issued in a series of selected reports, of which the present publication, dealing with fibres, is the first, and this will be followed by reports dealing with other materials.

The present publication includes reports on all the more important investigations on fibres and fibrous materials which have been carried out in the Scientific and Technical Department during the years 1903-1907. The subject of cotton is omitted from the present collection, since this subject has been dealt with in the recently published Report by the Director of the Imperial Institute on British Cotton Cultivation (Colonial Reports, Miscellaneous No. 50 [Cd. 3097]).

It has been found convenient to arrange the reports on fibres in the following three classes: (1) Textile fibres proper, including the vegetable fibres used in the manufacture of fabrics, such as flax and jute, and animal fibres, such as wool and silk; (2) fibres suitable for the manufacture of cordage, such as Manila, Sisal, Mauritius, and New Zealand hemps; (3) miscellaneous fibres, including the flosses or "silk cottons" which are employed as

stuffing materials in upholstery, the fibrous materials suitable for papermaking, and other products which do not fall into either of the first two classes.

In order to facilitate reference, a copious index has been added.

The experimental enquiries on which these reports are based have been conducted in the Laboratories of the Scientific and Technical Department, and have included, besides a microscopical examination and a determination of the physical properties of the fibres, a chemical investigation of their principal constituents, which has been chiefly carried out by Dr. Ernest Goulding, and latterly also by Mr. R. G. Pelly. The enquiries into the physical characters and possible technical applications of the fibres have been mainly conducted by Mr. F. W. Barwick, now Mercers' Company's Research Fellow in the Department. Finally, the fibres have been submitted for further tests to the appropriate commercial expert or firm of manufacturers, and in this connection I may specially refer to the assistance which has been rendered to the Imperial Institute by the following: Messrs. C. E. Collyer, Hanson and Orth, W. H. Hindley and Co., Ritchie and Co., Slann and Davies, Wigglesworth and Co. (London), Corrie, Mackie, and Co. (Dundee), Foster and Co. (Selby), and the Dundee Jute Spinners' Association. To the great knowledge and experience of the late Sir Thomas Wardle we have been greatly indebted for valuable assistance in all questions relating to silk.

I also desire to mention here the liberality of the Mercers' Company, who have recently made a grant to the Department which has rendered it possible to endow a Mercers' Company Research Fellow, more especially for the purpose of conducting investigations into the possible technical applications of new or little known fibres.

WYNDHAM R. DUNSTAN.

March, 1909.

METHODS OF INVESTIGATION.

The methods which have been employed in the chemical examination of vegetable fibres are based on those described by Cross and Bevan (*Report on Indian Fibres and Fibrous Substances*). The following is a summary of the processes adopted, together with an indication of the manner in which the results are interpreted.

Moisture.—The amount of moisture is determined by drying a specimen at 100-110° C. It is to some extent an index of the susceptibility of the fibre to attack by hydrolytic agents. Textile fibres of the highest class are distinguished by their relatively low moisture content. Owing to the variation of this constituent (1 to 2 per cent.) with changes in the hygroscopic state of the atmosphere, all the other results of analysis are expressed as percentages of the dry fibre.

Ash.—The percentage of ash is determined by completely incinerating the fibre and weighing the residue. An abnormally

large percentage of ash usually indicates the presence of mineral impurity introduced during the preparation of the fibre.

a-Hydrolysis.—The fibre is boiled for five minutes with dilute solution of sodium hydroxide (1 per cent. Na_2O), and is then washed free from alkali, dried, and weighed. The loss in weight indicates the amount of substance removed by the solvent action of the alkali.

β-Hydrolysis.—Another portion of the fibre is boiled for an hour with alkali of the same strength. In this case, the loss in weight includes not only the substance removed by the solvent action, but also that rendered soluble by the "degrading" action of the alkali. It is evident, therefore, that the difference between the values obtained on *a* and *β*-hydrolysis indicates the susceptibility of the actual fibre substance to attack by hot, dilute, caustic alkali.

The results yielded by these determinations afford an indication of the ability of the fibre to resist prolonged exposure to moisture and the attack of alkaline liquids with which the fibre may be treated during the processes of manufacture.

Mercerisation.—The fibre is left at the ordinary temperature in contact with concentrated sodium hydroxide solution (33 per cent. Na_2O) for an hour. It is afterwards thoroughly washed with cold water, dried, and the loss of weight determined. The visible effects of this treatment are generally a shrinkage in length of the strands of fibre and the production of a wavy and crinkled outline. The chemical effect consists chiefly of hydration changes. The result of the determination indicates the power of the fibre to withstand the action of strong caustic alkali.

Nitration.—The fibre is submitted to the action of a mixture of equal volumes of concentrated nitric acid (sp. gr. 1·42) and sulphuric acid (sp. gr. 1·84) for one hour at the ordinary temperature. It is then removed, allowed to drain for a few moments, and transferred to a beaker containing a large volume of water. After the fibre has been washed free from the acid, it is heated with water until boiling commences, and is finally dried in the water-oven. The increase in weight is noted. A comparison of the numerous results recorded in the following pages shows that, in general, the increase in weight on nitration bears a direct relation to the other chemical constants.

By the process of nitration, the celluloses are converted into their nitrates giving a corresponding increase in weight. The lignocelluloses, of which jute may be taken as a type, furnish bright orange-coloured products, whilst those of the pectocelluloses, such as flax, are colourless, or nearly so.

Cellulose.—The fibre is boiled for five minutes with a solution of dilute sodium hydroxide (1 per cent. Na_2O), is washed free from alkali, and, while still moist, is exposed to the action of chlorine gas for one hour; in some cases, a long exposure is necessary. It is then washed and treated with a solution of sodium sulphite, which is slowly heated until it boils; after two or three minutes' boiling, the product is collected on a calico filter and washed; it is afterwards treated with acetic acid (20 per cent.) and again washed, dried, and weighed.

When the chlorinated fibre is immersed in the sodium sulphite solution, a brilliant purple or crimson coloration is produced if the fibre belongs to the lignocellulose type, whilst in the case of non-lignified fibres, the solution remains practically colourless.

In this method of determining the percentage of cellulose, the non-cellulose substance is rendered soluble and removed, whilst the true cellulose is not attacked. The percentage of true cellulose in a fibre is the most important criterion of its composition and value. A good fibre contains 75-80 per cent., or even more.

Acid Purification.—The fibre is put into acetic acid (20 per cent.), which is slowly heated until it boils; the fibre is removed, washed first with alcohol and afterwards with water, and then dried and weighed. The loss in weight is chiefly due to the removal of casual impurities.

Length and Diameter of Ultimate Fibres.—A portion of the cellulose, obtained in the manner described above, is placed in dilute acetic acid, teased out with needles, and mounted on a glass slip. The length and diameter of a number of fibres thus separated are determined by means of the microscope, and the maximum, minimum, and average measurements are recorded. These constitute very important factors in the valuation of fibres, and are of assistance in determining their suitability for different manufacturing purposes.

TEXTILE FIBRES.

ANIMAL FIBRES.

The animal fibres examined at the Imperial Institute during the period covered by this series of reports consisted of wool and silk. The results of the examination of these materials, together with information given in reply to an enquiry with regard to the rearing of Angora Goats in Uganda, are dealt with in the following pages.

Wool.

Four classes of wool are usually recognised, namely, British wools, crossbred wools, Merino wools, and wools of a miscellaneous character such as East Indian, Chinese, &c.

British wools consist of long "lustre" wool, short "down" wool, and "half-breds," *i.e.*, the wool obtained from the first crosses between two distinct varieties of sheep.

Crossbred wools, which are largely imported into this country from Australasia, South America, the Falkland Islands, and the United States, are produced by cross-breeds—other than "half-breds"—of long lustre-wooled sheep with merino sheep.

Merino wool is obtained from sheep which have been bred, either directly or indirectly, from the Spanish merino—a sheep

bearing a very fine and valuable variety of wool. Large quantities of merino wool are produced in Australasia, South Africa, South America, and the Continent of Europe. An account of the production of wool in British Colonies is given in the Bulletin of the Imperial Institute, 1905, **3**, 176.

The total imports of sheep's wool of all varieties into the United Kingdom in 1907 were 759,237,245 lb., valued at £32,693,011. Of this 622,104,166 lb., valued at £27,149,645, were contributed by British Possessions. The amounts furnished by the different parts of the Empire were as follows: Australia, 321,470,554 lb., of value £14,587,701; New Zealand, 158,406,255 lb., of value £7,657,013; South Africa (Cape of Good Hope and Natal), 91,606,138 lb., of value £3,307,587; India, 46,583,905 lb., of value £1,449,955; Falkland Islands, 3,650,475 lb., of value £136,752; other British Possessions, 286,839 lb., of value £10,637.

Experiments in sheep-breeding and the production of wool are being carried out in several British Colonies, including the East Africa Protectorate, Rhodesia, and the Transvaal.

An account of the examination of three samples of wool from the East Africa Protectorate is given below.

East Africa Protectorate.

Sample No. 1 was labelled "First crossbred wool from native ewe and merino ram. From lambs six months old." This wool was dirty, irregular, and of uneven colour, varying from dark brown to yellow. Coarse hairs resembling "kemps" or dead fibres were present to an unusual extent (probably over 50 per cent.). The wool also contained a small quantity of burrs. The strength and elongation of the normal wool fibres were found to be equal to those of an ordinary merino wool. The fibre broke under a strain of 3 grams and showed an elongation of 40 per cent.

Microscopical examination showed that the normal wool resembled a fine variety of merino and had a diameter of 0·0004 to 0·0006 inch. The fibre was wavy and had a well marked scale structure. The diameter of the individual fibres was fairly uniform throughout their length. The coarse hairs were hard and brittle, possessed no scale structure, and had a diameter of 0·0012 to 0·004 inch. The length of the wool was about 1·5 inches, but owing probably to lack of skill in shearing, much short fibre was also present. It was found that, on scouring, the sample yielded about 50 per cent. of clean wool which was still, however, much discoloured.

Owing to the very large proportion of coarse hairs present the wool was regarded as being unsuitable for spinning. It was suggested that a great improvement in the quality of the product could be effected by good shepherding and careful breeding, since flocks require to be carefully tended and new blood frequently introduced, otherwise the "crossbred" sheep will quickly revert to the original native type.

Sample No. 2 was stated to have been clipped from a native ewe and Welsh ram crossbred lamb, six months old. The wool resembled the preceding sample in colour, but contained a smaller proportion of coarse hairs, and was therefore a little softer and more "woolly." The normal wool fibre broke under a strain of about 6 grams, showed an elongation of 38·5 per cent. and in these respects was equal to a commercial sample of crossbred wool of similar type.

Microscopical examination showed that the normal wool was fine, wavy, varied in diameter from 0·0006 to 0·0012 inch and had a well developed scale structure. The diameter of the individual fibres was fairly uniform throughout their length. The coarse hairs had a diameter of 0·002 to 0·006 inch, were hard and horny, and exhibited no scale structure. The normal wool varied in length from 1·6 to 2 inches and contained fewer short fibres than the preceding sample. It was found that, on scouring, the sample yielded about 60 per cent. of clean wool, which varied in colour from yellow to brown.

This wool was reported as being of no commercial value for spinning purposes. Although the sample was better than No. 1, it nevertheless contained a large proportion of coarse hairs. The influence of the Welsh blood was very marked in increasing the length, strength, and coarseness of the fibre; the product had, however, some of the characteristics of merino wool. If this wool could be produced free from coarse hairs and of better colour, it would be of good value as a fine "crossbred."

Sample No. 3 was stated to have been clipped from a native ewe and Clun Forest ram crossbred sheep. It consisted of wool which was of the first clip and was more distinctly of a crossbred type than either of the preceding samples. The product was fairly clean, varied in colour from white to reddish-brown, and contained fewer coarse hairs than either of the other specimens. The normal wool fibre broke under a strain of about 5·5 grams, and showed an elongation of 35 per cent. On microscopical examination the normal wool fibre was seen to be wavy, 0·0005 to 0·0012 inch in diameter, and to possess a very well-marked scale structure. The individual fibres were of fairly uniform diameter throughout their length, but were not so good in this respect as the other samples. The coarse hairs were 0·0016 to 0·0045 inch in diameter and were strong, coarse, and wiry. A small proportion showed some indication of scale structure, but as a rule the fibres were smooth and opaque. The length of the normal wool varied from 1·8 to 2·7 inches whilst the hairs were about an inch longer. It was found that, on scouring, the sample yielded about 50 per cent. of clean wool which was generally of good colour.

This wool was more promising than either of the other samples, since it had a better and more uniform colour and contained fewer coarse hairs. The proportion of hair was still large, however, and the product was therefore unsuitable for the market.

In conclusion, it was pointed out that wool containing so large a proportion of hair would have little or no commercial value and would meet with no demand in the English market.

At the time of forwarding the report, particulars were asked for regarding the type of native sheep. In reply, it was stated that the native sheep is the fat-tailed sheep of Africa and Asia, and that the East African animal is a particularly mixed type of this sheep with a covering resembling hair rather than wool. A three-quarter-bred Welsh lamb was said to show signs of yielding true wool, but the half-bred sheep did not yield any fleece other than about half a pound of the mixed wool and hair, such as that represented by the samples sent for examination.

SILK.

Silk-worm cocoons may be roughly divided into two classes, namely, those which are capable of being reeled or unwound in one continuous filament, and cocoons which have been so damaged by the egress of the moths that reeling is no longer possible, and which must therefore be treated by preparing and spinning machinery in order to form thread or yarn which is known as "spun silk." The waste silk produced in reeling the best cocoons is also utilised in the manufacture of "spun silk."

The first class comprises the cocoons of the mulberry silk-worm (*Bombyx mori*), other species of *Bombyx*, and also several varieties of semi-domesticated tussur silk-worm cocoons such as *Antheræa paphia* (syn. *A. mylitta*), the Indian tussur silk-worm, *A. pernyi*, the Chinese tussur silk-worm, and *A. yamamai*, the Japanese tussur silk-worm.

In the second class all the unreelable silk-worm cocoons are included, amongst which may be mentioned "Eri" silk cocoons (*Attacus ricini*), wild tussur cocoons and African wild silks.

Silk is imported into the United Kingdom principally from China, France, and India. The total imports of raw silk, excluding waste, in 1907 were 1,195,366 lb., valued at £916,890. Of this quantity, 217,015 lb. valued at £161,865 were contributed by British Possessions. India (principally Bengal) furnished 214,146 lb., valued at £159,725. Other British Possessions furnished 2,869 lb., valued at £2,140. In addition to the above amounts of raw-silk, silk-waste, husks of silk, and waste noils were received to the value of £629,400, the amount of which from British Possessions was £145,693.

Experiments in the rearing of silk-worms are being carried out in many parts of the British Empire, and the question of commercially utilising wild silk, which is found in several Colonies and Dependencies, is also being considered. (*See* note on African Wild Silk, p. 13).

The tussur silk industry of Bengal has gradually declined during recent years, and on this account the Bengal Department of Agriculture have inaugurated tussur silk-worm rearing experiments on model farms in the most important tussur districts of the Province, and it is hoped that by these means, the stock will be strengthened and the decline in the industry arrested.

Experiments were conducted in Burma during 1903 and 1904 with the rearing of the European silk-worm (*Bombyx mori*), but

owing to the premature hatching of the eggs before the food-stuff was ready for the worms, and to the probable defects in the methods of rearing the worms, the experiments proved a failure.

In 1897, steps were taken to develop a mulberry silk-worm rearing industry in Kashmir, and since that time the production of raw silk has steadily increased. In 1900 57,921 lb. of raw silk were produced, in 1906 the amount had increased to 190,736 lb., and in 1907 a further increase was reported. There is now a systematic cultivation of the mulberry tree in Kashmir, and the silk-worm eggs are given out to the villagers whose wives and families are occupied in rearing the silk-worms. It is estimated that between 60,000 and 70,000 persons are engaged in the industry.

An account of the examinations of silk-waste from Broussa, Turkey, silk-cocoons from Ceylon, and African wild silk is given in the following pages.

Turkey.

A sample of silk-waste received for examination and valuation in 1905 consisted of loose silk mixed with the inner portions of the cocoons. The product was white, contained a quantity of leafy matter and silkworm excrement, and had not been de-gummed. A small specimen of the material, after being scoured, was examined microscopically and found to possess the characteristic structure of silk and to have a diameter varying from 0·0003 to 0·0006 inch.

The commercial experts to whom the sample was submitted reported that there was not much demand for the material in this country and that it was not worth more than a few pence per lb.

Ceylon.

A sample of pierced "Eri" silk cocoons which was forwarded for examination by the Ceylon Agricultural Society in 1907 consisted of cocoons which varied in length from 1·5 to 2·5 inches and were about 0·75 inch in diameter. The weight of single pierced cocoons varied from 0·3 to 0·57 gram. The sample contained 28 per cent. of deep reddish-brown cocoons, the remainder being white. The cocoons were irregular in shape, and pointed at one or both ends; they were soft, of loose texture, and generally pierced.

The silk obtained from the white cocoons was usually of normal strength, whereas that from the red variety was weak. The diameter of the double fibre varied from 0·0012 to 0·0018 inch, with an average of 0·0014 inch, whilst that of the single filaments ranged from 0·0006 to 0·0008 inch, with an average of 0·00071 inch. Microscopical examination showed the fibre to have the characteristic structure of "wild silk."

These cocoons were of satisfactory quality and could readily be carded and spun for the manufacture of "spun" silk.

"Eri" cocoons occur promiscuously in two colours, brick red and white. Great difficulty is experienced in bleaching and

dyeing the red cocoons, and it was therefore advised that these should be eliminated if possible by selection of seed during about six successive rearings. The value of the silk would be considerably enhanced if the cocoons were obtained uniformly white. The silk from these cocoons could be utilised for mixing with Indian or Chinese Tussah silk, but the market value of the cocoons would vary considerably according to the demand for spun-silk fabrics. The value of the sample submitted was stated by experts to be about 1s. per lb. in this country (Sept., 1907). Cocoons of this type are however used principally on the continent, but owing to the small quantity sent for examination samples could not be submitted to European manufacturers. It was suggested that a larger sample of a few pounds of the cocoons, preferably of the white variety, should be forwarded so that further enquiries might be made and the commercial possibilities of Eri cocoons definitely determined.

Transvaal.

Two samples of silk cocoons were forwarded for examination to the Imperial Institute in May, 1907, from the Transvaal.

Sample No. 1.—The cocoons in this sample were pale golden straw colour and varied from 1·1 to 1·7 inches in length. The weight of the single cocoons varied from 0·26 to 0·91 gram with an average of 0·485 gram. They were oblong in shape with rounded ends, and somewhat constricted in the centre. The cocoons were generally firm and hard, but about 10 per cent. were found to be weak. There were no pierced cocoons in the sample, but double cocoons were occasionally noticed. The strength of the fibre was normal. The diameter of the double thread from the cocoons varied from 0·0009 to 0·0015 inch, with an average of 0·0012 inch, whilst that of the single scoured filament varied from 0·0004 to 0·0007 inch with an average of 0·0005 inch.

Sample No. 2.—These cocoons were of pale golden straw colour and varied in length from 1·0 to 1·5 inches. The weight of the single cocoons varied from 0·25 to 0·65 gram with an average of 0·362 gram. They were similar in form to those of the previous sample and were generally firm and hard, but about 12 per cent. were found to be weak. There were no pierced cocoons in the sample, but double cocoons were occasionally noticed. The strength of the fibre was normal. The diameter of the double thread from the cocoons varied from 0·0009 to 0·0015 inch with an average of 0·0012 inch, whilst that of the single scoured filament varied from 0·0004 to 0·0006 inch, with an average of 0·00047 inch.

The commercial value of these two samples would probably be about 3*s.* to 3*s.* 6*d.* per lb. for the dry cocoons.

The fine silk obtained from each sample after reeling and scouring was of very good colour, soft, and exceedingly lustrous. Although not so large as cocoons from the Cevennes the samples were of promising quality and in good condition for reeling.

The results of these experiments on silk-worm culture in the Transvaal showed great promise of success, but it was advised

that the development of the industry should be cautiously proceeded with. It is usually found more satisfactory to cultivate the silk-worms as a domestic industry than on extensive commercial lines, as in this way much of the spare time of the women and children may be profitably utilised. The cocoons thus produced might be collected and offered for sale in sufficiently large quantities to command the current market price. The freight on such a light bulky product as silk-cocoons being very considerable, the necessity for some arrangement whereby they might be collected and reeled in the colony was pointed out.

African Wild Silks.

Specimens of a wild "silk" were recently forwarded from Uganda, and have been examined in the Scientific and Technical Department.

The silkworm (*Anaphe* sp.) feeds principally on the leaves of species of *Ficus*, but the cocoons are found in almost all the forest trees. The caterpillars spin a large nest, inside which they form their cocoons in considerable numbers, varying from 10 to 100 or more. These nests are composed entirely of "silk"; the outer layers are of somewhat loose texture, whilst the inner part is firm and paper-like, but on degumming, each portion yields the same silky material. It seems probable that the whole of this product may be capable of utilisation as "spun" silk. On examining the cocoons it has been found possible to reel a small quantity of silk from selected specimens, but usually they are too loose to allow the reeling to be satisfactorily carried out.

Technical trials have shown that the whole of the silk can be spun into lustrous yarns which can be dyed without difficulty.

Similar cocoons have been received from Southern Nigeria, Northern Nigeria and Nyasaland. In Southern Nigeria the silk is used by the natives in conjunction with cotton for making the so-called "soyan" or "sanyan" cloths.

There appear to be several varieties of these silkworms, and they probably occur in many parts of Africa. The following information, with reference to their identification, has been obtained.

The silk cocoons of Southern Nigeria used for the "soyan" cloths are probably those of *Anaphe infracta*. A better known species, *Anaphe panda*, occurs in Natal and produces similar nests, which are, however, generally large and contain a greater number of cocoons. *Anaphe venata* has been found to the west of Kumassi, *Anaphe ambrizia* is recorded from Northern Nigeria, Uganda, and Mashonaland, and *Anaphe Moloneyi* has been observed in Uganda and Northern and Southern Nigeria.

If the rearing of these silkworms is undertaken as a native industry, precautions will have to be taken against parasites. Certain species of *Anaphe* appear to be attacked by a Hymenopterous insect, *Cryptus formosus*, and by a dipterous insect, *Tachina* species. These parasites pass their larval period inside the silkworm, destroying the host and utilising the cocoon as a protection for their own pupal stage. The entire subject is still under investigation.

Mohair.

Mohair is obtained from the Angora goat, which is said to be indigenous to Western Asia. It is largely bred in the Turkish province of Angora, whence the goat has derived its name.

Mohair of good quality is milky white in colour, and is the most lustrous of all varieties of wool and hair. The length of the fibre varies from four to ten inches or more, according to the time it is allowed to grow before being clipped. The uses to which mohair is applied are to a certain extent limited on account of the somewhat wiry nature of the material. It is for the most part employed in the manufacture of so-called "lustre" dress fabrics and other bright textile materials, such as linings, plushes and braids. An account of the production and uses of mohair is given in the Bulletin of the Imperial Institute, 1906, **4**, 150.

Mohair is exported principally from South Africa and Turkey. The total imports into the United Kingdom in 1907 amounted to 31,334,401 lb., of the value of £2,027,845. Of this quantity, 17,607,709 lb. valued at £1,135,489, came from Cape Colony, and 1,517,716 lb., valued at £82,389, from Natal. Other British Possessions furnished 13,033 lb., of the value of £585.

The rearing of Angora goats is claiming the attention of farmers in several British Colonies, of which mention may be made of Queensland, New South Wales, Victoria, Western Australia, New Zealand, and the Orange River Colony. In the last-mentioned colony, a prohibitive export duty of £100 is levied on each Angora goat taken from the colony. The prohibition also extends to other South African States.

An enquiry was received from Uganda in 1907 stating that the Commissioner was anxious to experiment with the rearing of Angora goats in the Protectorate, and that difficulties were being experienced in procuring the necessary goats, owing to the high export duties which were levied by the Governments of South African Colonies, where efforts had been made to obtain the goats. The object of the enquiry was to ascertain where Angora goats might be obtained, and whether there was any restriction with regard to purchasing them.

In reply, the following information was given. The exportation of Angora goats from Turkey is prohibited, yet notwithstanding this, several lots have been obtained, from time to time, from that country. In some cases, it has been found possible to obtain a revocation of the edict of prohibition, and, failing this, the goats have been purchased privately and surreptitiously conveyed from Turkey. In the United States and in Australia the Angora goat is bred with some measure of success, and well-bred goats might possibly be obtained from the latter country. Sales of Angora goats have been conducted in recent years by the Department of Agriculture of Western Australia, and also by farmers in Queensland and New South Wales. The price of the goats in Australia varies from £2 2*s.* to £5 5*s.*, and in view of the fact that the industry has not assumed any considerable proportions in Australia, it is not likely that prohibitive export duties will be levied.

FLAX.

Flax, the bast fibre of the stems of *Linum usitatissimum* (Common Flax or Linseed), is cultivated chiefly in Russia, Holland, Belgium, France, Ireland, Italy, Germany, and Austria. The finer qualities of the fibre are used for the manufacture of linen goods, whilst the coarser qualities are employed for making twine and canvas. An effort has been made during recent years to establish flax-growing at Behar in India, and the results obtained hitherto appear to indicate that this industry will be carried on in the near future on a commercial scale, and with considerable profit. Experiments have also been made in Cyprus, the East African Protectorate, Transvaal, Orange River Colony, and Canada. Samples of the products obtained in some of these experiments have been submitted to the Imperial Institute for examination, and are described in the following pages:—

CYPRUS

A small bale of flax straw from which the seed had been removed, and a similar quantity of the fibre which had been retted in the island, were forwarded for examination by the Director of Agriculture.

I. *Flax Straw.*—The flax straw, which had been retted but not broken and scutched, was straight and but little branched. The colour was pale brown or greenish-yellow, and the length varied from 18 to 28 inches. The fibre was fairly easily separated by hand from the straw.

On comparing the sample with a standard sample of flax grown in Belgium, the following results were obtained:—

	Flax Straw from Cyprus.	Flax Straw from Belgium.
Length of Straw . .	18 to 28 inches.	30 to 36 inches.
Diameter of straw -		
Maximum . .	0·068 inch.	0·064 inch.
Minimum . .	0·003 „	0·032 „

It will be seen from the foregoing figures that the flax straw from Cyprus was shorter than the standard Belgium sample used for comparison, but that the maximum and minimum diameters were approximately the same. The sample from Cyprus, however, contained a larger proportion of fine straw.

II. *Flax Fibre.*—This sample consisted of flax fibre obtained after breaking and scutching. It contained a quantity of broken straw or "shieve," but most of this could be separated by shaking. The colour was light or greyish brown, and the length of the filaments or strands of fibre was the same as that of the straw, *viz.*, 18 to 28 inches. The strength of the fibre was somewhat uneven, some portions being very weak. This defect suggested that the material had not been uniformly retted.

The following results were obtained on comparing this sample with a standard sample of Belgian flax:—

	Flax from Cyprus.	Flax from Belgium.
Length of strands of fibre	18 to 28 inches.	30 to 36 inches.
,, ,, ultimate fibres	0·2 to 0·9 inch. (average 0·4 inch)	0·3 to 1·1 inch. (average 0·6 inch)
Diameter of fibres (average)	0·0008 inch.	0·00086 inch.

It will be noticed that the flax from Cyprus contained slightly shorter and finer ultimate fibres than the commercial Belgian sample used for comparison.

Flax represented by these samples from Cyprus would not be suitable for the manufacture of linen cloth. The partially cleaned sample had been very imperfectly scutched, and one end of the straw had not been "broken." For this reason the flax was not in a suitable condition for manufacture, except, perhaps, for rough bagging material. It is probable that the straw could be more perfectly and evenly scutched if it were retted for a slightly longer period. It was also recommended that care should be taken to ensure that the straw is entirely submerged during the retting process. The difficulty in cleaning one end of the straw may have been due to the bundles having been placed on end with the upper portions slightly above the surface of the water, with the result that the straw had not been evenly subjected to the retting action.

The large quantity of fine straw present in Sample I suggested that the seed had been sown too thickly, and consequently the straw had become attenuated. It was pointed out that the quantity grown should be just sufficient to prevent branching of the straw and at the same time to allow each plant the necessary light and air. It is usual to sow about 3 bushels of seed per acre; if more than this quantity was used, it would probably be found necessary to thin out the young plants.

The commercial expert to whom the sample was submitted reported that the fibre had been ruined for spinning purposes by leaving the ends uncleaned. If however, the material had been properly prepared, although hard and lacking in "spinning quality," it might have been worth about £20 per ton. In the condition of the sample it could not be used in the linen trade, but might realise £10 to £12 per ton for mixing with common jute for the production of very coarse bagging.

From the foregoing particulars it will be realised that this flax from Cyprus could not compete with Belgian flax for textile purposes, unless the growth could be improved and the cleaning done more efficiently. It was therefore recommended that action should be taken on these lines and further samples submitted for examination and report.

EAST AFRICA PROTECTORATE.

A sample of flax, grown in the Highlands of the East Africa Protectorate, was sent to the Imperial Institute by a commercial firm at Nairobi, who stated that the fibre was known as "Lin flax," and was grown at an altitude of about 5,600 feet.

The sample consisted of two bundles of flax fibre, weighing $1\frac{1}{2}$ lb., which had been retted and broken. Most of the "shive" or broken particles of wood had been removed in the scutching operation, but a small quantity remained in the sample. The fibre was lustrous and greyish-brown in colour. The strength was fairly good, and the length of the strands of fibre was 24 to 32 inches. The diameter of the strands was 0·0025 to 0·020 inch, and of the ultimate fibres 0·00056 inch with a variation between 0·0003 and 0·0009 inch. Microscopic examination showed that the fibre had the characteristic structure of flax.

The appearance of the sample suggested that the flax had been over-retted; consequently the fibres separated easily, and an abnormally large quantity of waste would be produced in the processes of manufacture. Fibre of this character is known in commerce as flax codilla. It is the product of over dew-retted flax straw.

The commercial value of flax codilla of the quality of the sample would be about £26 per ton delivered in Dundee. At the time of the report this class of material was in considerable demand, and the price quoted is about £3 or £4 above the ordinary value.

The straw from which the fibre was produced would no doubt have furnished with proper treatment the true flax of commerce, and also given a larger yield. Such fibre would be worth to-day from £30 to £35 per ton.

The quality of the sample indicated that further experiments in flax-growing might well be made in the district where this fibre was produced.

TRANSVAAL.

A sample of flax, grown at Potchefstroom, was sent for examination by the Acting Director of Agriculture. The yield of dry straw was stated to have amounted to 966 lb. per acre.

The sample consisted of unretted flax straw, bearing mature seed capsules. The straw had a maximum length of 36 inches, and was hard, woody, and much branched. It was exceptionally coarse, the average diameter being double that of good commercial flax straw grown in Belgium.

On retting the straw, a light yellow fibre was obtained which was soft to the touch, of good lustre, but of rather poor strength. Microscopical examination showed the fibres to be fine and regular, and to have the characteristic structure of flax.

It was pointed out that flax straw of this quality would have little commercial value. The chief defects were the branching of the stalks and the presence of an abnormal quantity of coarse woody tissue in the straw. These faults were probably due to the seed having been sown too sparsely.

When the flax plant is grown for fibre, and not for seed, the straw should be gathered before it is fully mature, that is, before the stalks and seeds capsules have become entirely brown. If

the flax is left to grow until the whole stem is yellow or brown and the seeds are fully ripe, the fibre obtained would be coarse and of inferior quality.

ORANGE RIVER COLONY.

Three samples of flax were forwarded from the Agricultural Department of the Orange River Colony.

Sample No. 1 consisted of unretted flax straw which was hard and woody, much branched, bore a large quantity of mature seed capsules, and varied in colour from green to light brown. The length was very uneven, some of the mature stalks being only 8 inches long, whilst others had a length of 24 inches.

Comparison with a standard sample of Belgian flax straw showed that the sample under examination was much coarser.

		Flax Straw from Orange River Colony.	Flax Straw from Belgium.
Maximum diameter	...	0·200 inch.	0·064 inch.
Minimum diameter	...	0·018 inch.	0·032 inch.

Flax similar to this sample would be of no value as a source of fibre. The chief defects were the branching of the stalks and the presence of coarse woody tissue in the straw. The branching of flax straw and also the presence of hard wood constitute serious defects, which are caused by the sowing of an insufficient quantity of seed. The recommendations made regarding the Transvaal sample apply equally to this one from the Orange River Colony.

Sample No. 2 consisted of retted flax straw, which was hard and woody, but less branched than the preceding sample of unretted straw. The flax had been unevenly retted, many portions having been very much over-retted, with the result that the fibres, which had become entirely separated from the straw, were entangled and broken.

The length of the straw varied from 19 to 33 inches. The fibre was greyish-brown, and of rather poor strength. The ultimate fibres had a diameter of 0·0003 to 0·0009 inch, with an average of 0·00063 inch.

Sample No. 3 consisted of flax which had been retted and broken, most of the "shieve" or broken particles of wood having been removed. Owing to the straw having been over-retted, the fibre bundles in many cases had become broken up into short lengths from 4 inches upwards.

The flax resembled that obtained from the retted straw of the previous sample.

Samples 2 and 3 were of little or no value for spinning, owing to their having been greatly over-retted.

In perfectly retted flax the fibre will separate from the straw in the form of a ribbon of good strength with all the fibres adhering together, whereas in the samples under examination the fibre bundles had been either greatly weakened or resolved into short fibres by the prolonged steeping in water.

INDIA.

A sample of flax grown from Riga seed at the Bankipore Agricultural Experiment Station, was forwarded for examination by the Director of Agriculture, Bengal, and consisted of two bundles of unretted flax straw.

The straw was straight and generally not branched, except towards the upper parts. The colour varied from green to pale yellow. The fibre could be easily separated from the yellow portions by breaking the straw, thus indicating that the material had become partially over-ripe.

The following results were obtained on comparing the sample with a standard specimen of flax straw grown in Belgium.

	Flax Straw from Bengal.	Flax Straw from Belgium.
Length of straw... ...	30 to 42 inches.	30 to 36 inches.
Diameter—maximum ...	0·132 inch.	0·064 inch.
,, minimum ...	0·041 ,,	0·032 ,,

It will be noticed that the flax from Bengal was longer and coarser than the standard sample of Belgian flax used for comparison.

The clean fibre obtained from the Indian straw had an average diameter of 0·00091 inch, the diameter of the standard sample of Belgian flax being 0·00086 inch. The sample under examination was therefore generally coarser than the Belgian specimen.

The straw was well grown, but it seems probable that insufficient seed had been sown, as a considerable amount of wood had developed in parts of the straw. Advice was given as to the quantity of seed which should be sown per acre, and the age at which the straw should be pulled.

With greater care in cultivation it is highly probable that flax of excellent quality could be grown in that part of Bengal where the present sample was produced.

TURKEY.

Two samples of flax were forwarded by H.M. Vice-Consul, Broussa, Turkey, which appeared to have been submitted to a chemical bleaching process.

Sample No. 1.—This consisted of clean white fibre, which was lustrous, smooth to the touch, and much tangled. The length of the staple was irregular, ranging from as much as 10 inches down to 1 inch or even less.

On microscopical examination, the fibres were found to be usually united in bundles of 0·004-0·016 inch in diameter. The ultimate fibres themselves had an average diameter of 0·0008 inch, and exhibited the characteristic structure of flax.

This material appeared to be the short fibre obtained in some preparing or combing process. The longer fibres could be separated from it and spun into a yarn of medium quality, whilst the

very short fibres could be used for the manufacture of coarse yarn or as tow.

Sample No. 2.—This sample varied in length from about 12 to 20 inches, and the fibres were straight and parallel to one another. In other respects the product resembled Sample No. 1.

This material consisted of the "tops," or long fibres, which had evidently been straightened and prepared for spinning, and would no doubt furnish a yarn of good quality.

Commercial experts reported that these samples of flax were not of the quality usually met with in the English market, and that they appeared to have been submitted to chemical processes which might have caused injury to the fibre and would be prejudicial to the sale of the material. They expressed the opinion that the product would be saleable in this country, but that the fibre in its unbleached, natural state would probably find a better market.

A further sample of the flax was forwarded by the Vice-Consul at a later date, which had been retted and broken, but had not been treated chemically. Most of the "shieve" or particles of woody tissue had been removed in the scutching operation, but a small quantity remained in the sample. The flax was pale golden brown, of good lustre and soft to the touch, but of rather poor strength. The fibres varied in length from 22 to 30 inches, and in diameter from 0·0029 to 0·0145 inch. The ultimate fibres had an average diameter of 0·0005 inch.

The fibre from Broussa was similar in most respects to a standard sample of Belgian flax, but was slightly shorter and of inferior strength, whilst many loose fibres projected from the bundles. The two latter defects suggest that the material had been slightly over-retted.

A portion of the sample was submitted to commercial experts, who reported that the flax could be used by spinners of very heavy yarns, but that it was really more suitable for rope-making than for spinning. They stated further that the fibre appeared to have undergone a process of hackling at the ends, and it was feared that a consignment in bulk would not be equal, on the average, to the present small sample.

The commercial value of flax equal to the sample was estimated at £30 per ton in this country at the date of the report (June, 1906).

There is no doubt that manufacturers would prefer to receive this flax from Broussa in its natural unbleached condition rather than after it has undergone chemical treatment.

RAMIE.

Ramie, rhea, or China grass, the bast fibre of *Boehmeria nivea,* is cultivated very largely in China, where it is used extensively for the manufacture of the fabrics known as "grass-cloths." It is employed to some extent in Europe for weaving goods of various descriptions, such as lace, curtains, and wearing apparel, but its principal use at present is for the manufacture of mantles for incandescent gas lighting.

Experiments in ramie cultivation have been made in most of the British Colonies and Dependencies, and specimens of the products have, in some cases, been forwarded to the Imperial Institute for examination.

A short account of the cultivation of the ramie plant and the preparation and prospects of the fibre has been given in the Bulletin of the Imperial Institute, 1905, **3**, 55.

Cyprus.

A sample of ramie fibre, forwarded to the Imperial Institute by the Agricultural Department, Nicosia, in 1905, was stated to have been obtained from plants grown at Tricomo. It consisted of fibrous ribbons which were mostly about 3-4 feet long, but were, in some cases, only about 2 feet in length. These ribbons were of a greenish colour on the inner surface and dark brown and hairy on the outer surface. The dry, brown external layer could be detached to a considerable extent by rubbing the fibre between the hands.

A portion of the material was degummed in the laboratory by repeated boiling with dilute alkali and washing with water. The resulting fibre was silky, somewhat lustrous, and of a pale brown colour. On comparing this prepared fibre with a standard sample of unbleached ramie filasse, it was found to be slightly finer than the latter, but not quite so strong. This inferiority in strength may, however, have been due to the somewhat drastic method employed in degumming. The fibre from Cyprus had a diameter of 1/1200-1/500 inch, with an average of 1/850 inch, and a maximum length of 10 inches. On microscopical examination, the fibre was found to possess the characteristic structure of ramie. It is evident from these results that the present sample compared favourably with the standard sample.

In conclusion, it may be stated that the product resembled the ramie ribbons which are occasionally exported from India. The commercial experts reported that the nominal value of the material was about £15 per ton in the London market.

It was pointed out that whilst it is not desirable to discourage experimental ramie growing in Cyprus, great caution is necessary in advising anything like extensive cultivation of this plant.

East Africa Protectorate.

Six samples of ramie filasse from the East Africa Protectorate were forwarded to the Imperial Institute in 1906.

Sample No. 1, labelled "Ramie filasse, A," consisted of clean filasse. The colour varied from pale yellow to white, the specimen being slightly more yellow than a standard sample of ramie filasse. It was soft, of fairly good lustre, and had a maximum length of 6 feet 6 inches. The single fibres obtained from the bundles generally had a length of 8 to 9 inches.

Sample No. 2, labelled "Ramie filasse from China grass, B," consisted of clean filasse, which was pale yellow in colour and darker than sample No. 1. It was soft, of fairly good lustre, and had a maximum length of 6 feet. The single fibres generally had a length of 8 to 9 inches.

Sample No. 3, labelled "Ramie filasse, C," consisted of fairly clean filasse, which had a light yellowish brown colour and was darker than samples Nos. 1 and 2. It was fairly soft, of poor lustre, and had a maximum length of about 4 feet. The single fibres generally had a length of 8 to 9 inches, but shorter fibres were also present.

Sample No. 4, labelled "Ramie filasse, D," consisted of short entangled fibres, having the appearance of waste or "noils." The material was clean, of light yellowish brown colour similar to that of sample No. 3. It was fairly soft, but of poor lustre, and had a maximum length of 8 inches, shorter fibres being also present.

Sample No. 5, labelled "Ramie filasse, from green ribbons, E," consisted of very clean filasse. It varied in colour, half the sample being pale blue and the remainder an even white. It was soft, of good lustre, and had a maximum length of 4 feet. The single fibres had a maximum length of 9 inches.

Sample No. 6, labelled "Ramie filasse from China grass, F," consisted of filasse, which was very clean and of even white colour. It was soft, of good lustre, and had a maximum length of 4 feet. The single fibres had a maximum length of 10 inches.

The six samples were compared with standard samples of ramie fibre as regards the strength, elongation and diameter of the fibres, and the results are given in the following table. The mechanical tests were made by means of the Reeser and Mackenzie fibre-testing instrument.

—	Strength in grams.		Elongation at the breaking point in grams.		Diameter of fibres in mm.	
Standard Samples.	Average.	Variation.	Average.	Variation.	Average.	Variation.
1. Combed filasse	36·10	23·0—57·5	2·80	2·0—3·5	0·00157	0·0009—0·0030
2. Combed filasse	42·70	27·5—53·0	—	—	0·00125	0·00085—0·0020
3. Combed filasse	38·25	26·5—57·0	2·95	2·5—3·5	0·00162	0·0010—0·0024
4. Degummed ...	31·40	25·0—12·5	2·35	2·0—3·0	0·00165	0·0010—0·0029
5. Degummed ...	36·10	27·5—55·0	—	—	0·0012	0·00085—0·0020
Specimens from the East Africa Protectorate.						
1. "A."	32·94	22·5—50·0	3·58	2·0—4·5	0·00137	0·0008—0·0023
2. "B."	48·62	30·0—60·0	2·95	2·0—3·5	0·00157	0·0009—0·0025
3. "C."	41·60	27·5—55·0	3·05	2·0—4·0	0·00146	0·0009—0·0024
4. "D."	50·12	30·0—70·0	2·67	2·0—4·0	0·0019	0·0011—0·0030
5. "E."	36·19	25·0—57·5	2·66	2·0—4·0	0·00147	0·0008—0·0030
6. "F."	54·75	26·5—70·0	2·70	2·0—4·0	0·00147	0·0008—0·0022

From the foregoing results, it is evident that the strength of these ramie fibres from East Africa compared favourably in all

cases with that of the standard samples, in fact samples B, D, and F were distinctly superior in strength to the reference specimens.

In many of the samples the ultimate fibres had not been completely isolated, and in all cases the fibres were slightly entangled. The material would, on this account, be difficult to straighten and a somewhat large quantity of waste would be produced in the processes preparatory to spinning.

Samples A, B, and C were distinctly inferior in colour to the standard samples.

Sample D was short waste material, known commercially as "noils," which is often utilised to mix with wool.

Samples E and F were the most satisfactory specimens as regards colour and general appearance.

Specimens of the filasse were submitted to manufacturers of ramie yarn, who reported that it was difficult to give valuations of the samples as they were not in the condition in which ramie is usually offered for sale in this country. They stated that sample D could be sold here as "noils" or waste, but that the dark specks present in it would reduce its market value.

The samples were said to have been badly degummed, and it was not possible to judge what the textile value of the fibre would be if properly treated.

It appears that manufacturers prefer to degum ramie ribbons by their own processes, so as to produce filasse in the form most suited for their particular purposes. Consequently ramie fibre has only a ready sale in this country in the form of ribbons from which the outer brown pellicle has been removed.

It was suggested that a sample of such ribbons should be prepared in East Africa and forwarded to the Imperial Institute for further examination. The manufacturers who were consulted expressed their willingness to experiment with any samples of ribbons from new sources, in order to compare them with the material at present on the market. It was pointed out that in forwarding samples of ramie fibre to the Imperial Institute for examination it is always desirable to give some indication of the treatment which they have undergone. In the present instance no information whatever was supplied, and it was therefore not possible to pronounce any definite opinion as to the value of the processes employed.

North Eastern Rhodesia.

Two samples of ramie fibre were received for examination at the Imperial Institute from the British South Africa Company in 1906 which had been grown at the Government Experimental Gardens, Fort Jameson, North Eastern Rhodesia.

Sample No. 1, labelled "Ramie grown at Government Experimental Station, Fort Jameson, N.E. Rhodesia," consisted of partially prepared fibre, which was light yellowish-brown in colour, and had a maximum length of 3 feet.

The ultimate fibres generally had a length of 7 to 9 inches and an average diameter of 0·00108 inch, with a variation from 0·0007 to 0·0016 inch.

The ultimate fibres of ramie usually vary in length up to 11 inches and in diameter from 0·0008 to 0·003 inch, with an average of 0·0015.

A portion of the sample was boiled with dilute alkali, and, after this treatment, the fibre varied in colour from cream to white and possessed a good lustre.

Sample No. 2, labelled as the previous sample, consisted of partially prepared fibre, which was of a dull light reddish-brown colour, and had a maximum length of 3 feet 6 inches.

The ultimate fibres generally had a length of 7 to 9 inches and an average diameter of 0·0010 inch, with a variation from 0·0007 to 0·0016 inch.

This sample was also boiled with dilute alkali and furnished a fibre of very good lustre but of much darker colour than the previous sample.

These samples of ramie from Rhodesia would not be readily saleable in this country as they were not in the condition in which ramie is generally placed on the market, and had apparently been treated in some way to separate the fibres after decortication. It is usual to export the clean, scraped ribbons, as manufacturers apparently prefer to degum the fibre by their own processes. A sample of hand scraped China grass was forwarded with the report as an illustration of the form in which the material is received in this country. The current price of such material in the London market at that time was £32 to £36 per ton.

It was stated that if samples of the cleaned ribbons could be obtained from Rhodesia it would be possible to get manufacturers to test them in comparison with the material which is at present on the market.

CEYLON.

Samples of fibre and string were received from Ceylon in 1903. The fibre appeared to be that known as Rhea, Ramie, or China Grass, the value of which, when properly prepared, was at that time about £20 to £30 per ton. It was suggested that a trial consignment of a few hundredweights should be forwarded to test the market.

The string was regarded as worth about 9*d.* per lb. in the London market, but it was pointed out that most manufacturers prefer to purchase the fibre and spin the string in their own way.

JUTE AND SIMILAR FIBRES.

The fibres included in this class are derived from a number of plants of the *Tiliaceae* and *Malvaceae*. They consist of the bast fibre of the stem, and are prepared by a process of retting as exemplified by the method commonly employed in Bengal

for jute extraction (see *Bull. Imp. Inst.*, 1905, **3**, 254). The products are composed of highly lignified cellulose. They are weaker than flax or hemp and much less durable. The principal uses of these fibres are for the manufacture of coarse woven articles such as sacks and bagging, hessians, horse-cloths, and also for cheap cordage and for yarns employed in the weaving of carpets and rugs.

Jute, the bast fibre of *Corchorus capsularis* and *C. olitorius*, is exported in large quantities from India and chiefly from Bengal. The imports into the United Kingdom for 1907 amounted to 363,835 tons, of the value of £8,165,255.

During recent years, considerable extension of the jute spinning industry has taken place in India, and at the present time about half the total crop is used locally. In the period 1891-1906, more than £500,000 was expended in India on jute machinery. This increased utilisation of jute in India threatens to render it difficult for the jute spinners of the United Kingdom to obtain a sufficiency of raw material, and for this reason the jute importers of Dundee are desirous of obtaining information as to the possibility of cultivating jute or similar fibrous plants in West Africa.

The Prospects of Jute-growing in West Africa.

The true jute plant is stated to grow in West Africa, and certain similar fibres are prepared and utilized by the natives. The fibre collected by the natives, however, is not derived from the true jute plant, but is of a different nature.

From the facility with which the jute plant is cultivated and its fibre extracted, it seems very probable that numerous localities may be found in West Africa suitable for its cultivation, or for that of native plants yielding a similar fibre, and that the natives will be able to acquire the method of preparing the fibre for the market. This crop will not prove a rival to cotton, since it can be grown on land quite unfitted for the cotton plant.

The rainfall of the jute-growing districts of Bengal ranges from 50 to 100 inches per annum, in some places rising to 130 inches; most of the rain falls in the months April to October. In Freetown, Sierra Leone, the rainfall is 170 inches per annum, May to October being the wet months. In Lagos the average annual rainfall is about 60 inches, April to November, but excluding August, being the wet months; thus the climatic conditions seem likely to suit the growth of the plant. A trial of jute-growing was made in Gambia in 1897, and the fibre produced was strong, of good spinning properties, very well prepared, and was classed as being of medium quality and quite merchantable; the length was short owing to the season having been dry (*Kew Bulletin*, 1898, pp. 38 to 40). Gambia has a lower rainfall (about 50 inches per annum) and a shorter rainy season—namely, from the middle of June to the middle of October—than Sierra Leone, so the latter is more likely to be favourable for jute.

During the year 1906 a quantity of true jute seed was forwarded to the West African Colonies from India for the purpose of attempting the cultivation of the plant. It was proposed that experiments should be carried out at first on a small scale in order to ascertain the adaptability of Indian jute to West African conditions.

JUTE (*Corchorus* sp.).

WEST AFRICA.

Sierra Leone.—Considerable attention has been devoted to jute-growing in Sierra Leone, and much interest has been taken in it by the Government of that Colony. A Government agent was appointed at the beginning of the year 1905 to make a study of the fibres of the Ronietta District, and the results of this inquiry were embodied in a report, copies of which were forwarded to the Imperial Institute, together with samples of the three fibres mentioned in it. The plants from which these products were obtained are said to occur in all parts of the Protectorate.

Sample No. 1 consisted of a small quantity of fibre which was of a pale straw colour, well cleaned and lustrous, and about 5 feet 4 inches long. This product was stated to be known in the Mendi language as "Corwey," and was supposed to be derived from *Corchorus olitorius.*

Sample No. 2 was brown in colour, well cleaned, silky, lustrous, varied in length from 5 feet to 7 feet, and was alluded to as the product of *Corchorus capsularis.*

Sample No. 3 consisted of the fibre which is known to the natives of Sierra Leone as "Awkraw" fibre, and is derived from *Hibiscus esculentus.* This sample is described later (page 35).

The samples of jute were examined chemically as completely as was possible with the very small quantities available. The results are given in the following table, to which are added for convenience of comparison the results obtained with standard Indian jutes which have been examined in the Scientific and Technical Department of the Imperial Institute:—

—	1	2	Indian jute "Extra Quality."	Indian jute "Extra fine Quality."
Moisture, per cent. ...	10·4	10·3	11·1	9·6
Ash, per cent.	0·50	0·28	1·0	0·7
α-Hydrolysis, loss per cent.	6·8	6·8	8·5	9·1
β-Hydrolysis, loss per cent.	10·9	10·0	12·5	13·1
Cellulose, per cent. ...	78·8	77·1	79·0	77·7
Length of the ultimate fibres.	1·6—2·7 mm. or 0·06—0·11 inch.	2·1—3·7 mm. or 0·08—0·14 inch.	1·5—3·0 mm. or 0·06—0·12 inch.	

These figures indicate that both the samples of jute are of good quality. In some respects No. 1 is the best, especially in its richness in cellulose and its resistance to the attack of alkali, as shown by the comparatively small loss on hydrolysis. It is evident that this fibre compares very favourably with the standard Indian jutes.

Sample No. 2 also resembles Indian jute in both chemical and mechanical properties.

The commercial experts reported that samples No. 1 and 2 resemble Indian jute in their general character, but are not quite the same in all respects. Both samples are of good colour, and fair length and strength, but differ in sample No. 1 being harsher than No. 2. These fibres can be spun with good results when mixed with jute, and would readily find a market at prices rather lower than the current rate for Indian jute. Similar samples have been recently submitted to spinning trials, and the present value is given as from £16 to £16 10s. per ton in Dundee, the price of jute being from £16 to £25 per ton, depending on the quality.

It is evident from the results of this enquiry that Sierra Leone is capable of growing fibre of good quality and possessing the characters of jute. In view of the cultivation being started on a commercial scale, it was pointed out that it is important that the variety of seed to be sown should be carefully chosen, and that, if different qualities of fibre are obtained, the various grades should be kept separate.

Another sample of fibre—supposed to be true jute—from the Bandajuma District, was forwarded to the Imperial Institute by the Government of Sierra Leone in July, 1905. This product was rather harsh, of somewhat poor strength, and from 3 to 4 feet long. On chemical examination it gave results which are compared below with the corresponding figures furnished by a sample of Indian jute of "extra fine" quality:—

	Present sample from Sierra Leone. Per cent.	Indian jute of "extra fine" quality. Per cent.
Moisture	11·9	9·6
Ash	0·4	0·7
α-Hydrolysis (loss)	7·4	9·1
β-Hydrolysis (loss) ...	10·5	13·1
Cellulose	79·9	77·7
Length of ultimate fibre	1·4-3·0 mm. or 0·05-0·12 in.	

These results indicate that as regards its chemical composition and behaviour the fibre is of excellent quality, since it contains a high percentage of cellulose and suffers a comparatively small loss when boiled with dilute alkali (α- and β-hydrolysis). In these respects this product is somewhat superior to the sample of Indian jute referred to above. The length of the ultimate

fibre is identical with that of true jute. The amount of moisture contained in the Sierra Leone fibre under ordinary atmospheric conditions is, however, greater than the amount usually present in samples of true jute, and, moreover, the former product is weaker than a good jute. Microscopic examination showed that the fibre was certainly a member of the jute class, but was inadequate to prove identity with jute itself.

Two species of *Corchorus* are grown in Sierra Leone as vegetables, but are not worth consideration as possible sources of fibre in the present state of agriculture of the Colony. One species is called "Gambia Crincrin," "Gringri" (Mendi language), and "Angerincrin" (Timani language). The other is also known as "Crincrin" in Sierra Leone, "Eyo," "Ayoa," or "Owedu" (Yoruba language). These species are probably not indigenous, and are perhaps referable to *C. acutangulus* and *C. tridens.*

A specimen of the fibre of *C. capsularis* grown at Kangahun was composed of fine, soft, silky, lustrous fibre, of good colour but poor strength, and was valued at £22-£23 per ton (with "medium" jute at £22-£25 per ton). This fibre was well cleaned but had probably been over-retted.

Another sample from Sierra Leone consisted of unevenly prepared fibre about four feet long, of fair lustre, colour varying from pale buff to grey, and of irregular strength. Portions of the material were still gummy, but the greater part had been over-retted. The fibre was valued at £9 per ton (compared with Calcutta jute at £14 10s. per ton). Suggestions were made with reference to the retting process with a view to the production of a more regular and evenly cleaned product.

Southern Nigeria.—Two samples received from Lagos were matted, tangled and weak, and only suitable for use as tow. It was pointed out that the lack of strength was probably due to over-retting, which in future should be carefully avoided, and that it is important that the fibre should be kept straight and not allowed to become tangled.

A specimen of jute (*Corchorus olitorius*) grown on the Onitsha Plantation was harsh, of pale buff colour and fair lustre, and somewhat frayed. It was of poor strength and was valued at £14 10s. per ton (with "medium" jute at £14-£16 per ton). It seemed probable that this sample had also been retted for too long a period.

Northern Nigeria.—Two samples of jute from Northern Nigeria, one from imported seed, and the other from local native seed, were received for examination. The former consisted of soft, fine, greyish, fairly lustrous fibre, but was not very well cleaned. The fibre was about four feet long and was regarded by experts as very suitable for the best purposes of jute spinning, and worth £24 per ton (with "medium" jute at £23-£25 per ton). It was pointed out that the fibre could be considerably improved by more careful preparation. The sample grown from native seed was harsher and more brittle and not very well prepared. It was valued at £22 per ton.

A specimen of native jute cultivated by riverside villagers in Borgu Province, Northern Nigeria, consisted of nearly white, fairly well cleaned, rather harsh fibre, about five feet long and rather weak. On chemical examination it gave the following results:—

	Per cent.
Moisture	9·0
Ash	0·3
α-Hydrolysis (loss)	9·8
β-Hydrolysis (loss)	15·1
Acid purification (loss)...	0·1
Cellulose	76·5

These results show that the sample was on the whole of good quality. It was, however, slightly inferior to a specimen of "extra fine quality" Indian jute with which it was compared, as it contained less cellulose and suffered a greater loss on hydrolysis than the latter.

JUTE SUBSTITUTES.

There are many plants occurring in British Dependencies which yield fibres of similar character to jute and capable of replacing it in manufactures. From a commercial point of view the two most important of such plants are *Abutilon Avicennæ* and *Hibiscus cannabinus*. The former plant is a native of North Western India, but is not cultivated there as a source of fibre. The product is, however, largely exported from China, and is known in the market as "China jute." *Hibiscus cannabinus* is largely cultivated in India, and the fibre is known as "Ambari" or "Deccan hemp." This material is imported into the United Kingdom under the name of "Bimlipatam jute." Among other possible substitutes for jute may be mentioned the various species of *Hibiscus*, *Sida*, *Triumfetta* and *Urena*.

SUDAN.

Hibiscus cannabinus.

A small sample of the fibre of *Hibiscus cannabinus* was brought back from the Bahr-el-Ghazal by Mr. Harold Brown, who found the plant growing near Mallang's village to the south of Wau. It is possible that the plant is also cultivated for its fibre in other parts of the province.

The fibre, which had been prepared by the natives, consisted of nearly white lustrous ribbons marked with occasional brown stains. The fibre was well cleaned, but had not been combed; it was of good strength, and the length of staple varied from 3 to 4 feet.

The results of the chemical examination are given in the following table, to which are added for comparison the figures furnished by a sample of *Hibiscus cannabinus* fibre from India, and a specimen of Indian jute of "extra fine" quality:—

—	*Hibiscus cannabinus* fibre from Bahr-el-Ghazal.	*Hibiscus cannabinus* fibre from India.	"Extra fine" Indian Jute.
Moisture, per cent.	8·2	10·8	9·6
Ash, per cent.	0·7	1·0	0·7
α-Hydrolysis, loss per cent. ...	8·6	12·2	9·1
β-Hydrolysis, loss per cent. ...	13·4	19·1	13·1
Cellulose, per cent.	77·8	74·9	77·7
Length of ultimate fibre ...	1·6—3·2 mm.	3—4 mm.	1·5—3·0 mm.

These figures demonstrate that the Hibiscus fibre from the Bahr-el-Ghazal is much superior to the sample of the same fibre forwarded from India, and that it would probably be more durable. This is specially indicated by its greater resistance to the attack of alkali, as shown by the comparatively small loss on hydrolysis and by the larger proportion of cellulose which it contains. It is also evident that the fibre from the Bahr-el-Ghazal closely resembles Indian jute in its chemical behaviour and composition, and there is little doubt that it could be used successfully as a substitute for the latter product.

In view of these favourable results it was suggested that a larger sample of this fibre should be forwarded from the Bahr-el-Ghazal so that it could be examined more fully and submitted to experts for valuation, and that steps might also be taken to extend the cultivation of *Hibiscus cannabinus* in the Bahr-el-Ghazal with the object of producing the fibre in commercial quantities.

East Africa Protectorate.

Triumfetta semitriloba.

This sample of fibre was forwarded to the Imperial Institute by the Director of Agriculture, Nairobi, in September, 1904. It was very small, weighing only about ½ oz., and was not well prepared, a large part of the fibre adhering together owing to the material having been insufficiently cleaned. For these reasons it was impossible to carry out a complete chemical investigation, or to obtain a satisfactory commercial valuation. The fibre was strong, of a light-brown colour, and the staple varied in length from 6 to 8 feet. A part of the sample, after being carefully hackled, was examined chemically, and gave the following results:—

	Per cent.
Moisture	9·5
Ash	1·7
Loss on α-Hydrolysis	9·2
Cellulose	76·1

Length of ultimate fibre ... 1·8-3·9 mm. (0·07-0·16 in.)
Average ... ... 2·7 mm. (0·11 in.)

These figures show that the fibre is rich in cellulose, contains but a small proportion of mineral constituents (ash), and if properly prepared would be of good quality.

It is of interest to compare these figures with those furnished by the fibre of a closely allied plant, *Triumfetta rhomboidea*, a sample of which, grown in Nyasaland, has been examined at the Imperial Institute. The results given by a specimen of Indian jute of "extra fine quality" are also added for comparison.

—	*Triumfetta semitriloba* fibre.	*Triumfetta rhomboidea* fibre.	"Extra fine" Indian jute.
	Per cent.	Per cent.	Per cent.
Moisture	9·5	10·4	9·6
Ash	1·7	0·6	0·7
Loss on *a* Hydrolysis ...	9·2	9·1	9·1
Cellulose	76·1	76·2	77·7
Length of ultimate fibre	1·8—3·9 mm. or 0·07—0·16 in.	2·0—2·8 mm. or 0·08—0·11 in.	1·5—3·0 mm. or 0·06—0·12 in.

A consideration of this table leads to the conclusion that the Triumfetta fibres are very similar in composition, and that well-prepared samples of *T. semitriloba* would be probably in no way inferior to the fibre of *T. rhomboidea*. Both fibres closely resemble jute in chemical properties and composition, as well as in the length of their ultimate fibre. The sample of *T. rhomboidea* fibre was valued by commercial experts in September, 1904, at about £12 per ton in the London market.

From the results of this investigation, it is evident that the fibre of *T. semitriloba* possesses valuable qualities, and a larger and carefully cleaned sample of the fibre has been asked for, so that it may be more thoroughly examined, and its commercial value ascertained.

A sample of the fibre of *T. cordifolia* var. *Hollandii* has been received from the Gold Coast and is described on page 43.

NYASALAND

Sida rhombifolia and *Triumfetta rhomboidea*.

Samples of these fibres were forwarded to the Imperial Institute by the Scientific Department, Zomba, and were accompanied by a letter in which it was stated that the fibres are derived from plants known to the natives as "Denje" and "Nzonogwe." Both plants are stated to grow abundantly in the neighbourhood of Zomba and throughout the Shiré Highlands, and generally to occur in marshy places. "Nzonogwe" attains its greatest height on any marshy soil, whilst "Denje" grows well in the good, rich, deep soil of the slopes of Zomba. The fibre is said to have been prepared in the following manner:—

The stems are cut close to the ground, and scraped with a knife in order to remove the smaller branches and the rough, hairy epidermis. The bark is readily stripped from the stems, and the ribbons so obtained have an average length of 5½ feet. After these ribbons have been immersed in water for 14 days, the fibre is easily separated from the pulp, is cleaned by washing, and afterwards dried by exposure to the sun for 24 to 48 hours.

Botanical specimens of the plants, including flowers, leaves, and seeds, were forwarded by the Scientific Department, Zomba, to the Royal Botanic Gardens, Kew, with the result that "Denje" was identified as *Sida rhombifolia*, L., and "Nzonogwe" as *Triumfetta rhomboidea*, L.

The samples of fibre were examined in the Scientific and Technical Department of the Imperial Institute with the following results:—

Fibre of *Sida rhombifolia* ("Denje" fibre).

This sample consisted of about 1¼ lb. of prepared fibre and ½ lb. of dried ribbons of bark, the latter being about 5 feet long.

The prepared fibre was partly greyish and partly of a pale buff colour. It was fairly well cleaned, and had a length of 4½-5 feet. The results of its chemical examination are given below, together with those of two Indian specimens of this fibre and of a sample of Indian jute of "extra fine quality" which have been examined in the Scientific and Technical Department of the Imperial Institute.

—	*Sida rhombifolia.*			"Extra fine" Indian jute.
	From Nyasaland "Denje."	From Rahuta, Bengal.	From Rajshahi, Bengal	
Moisture, per cent. ...	10·3	12·7	12·7	9·6
Ash, per cent.... ...	1·0	1·6	1·4	0·7
α-Hydrolysis, loss per cent.	8·5	8·7	11·2	9·1
β-Hydrolysis, loss per cent.	13·5	14·5	14·8	13·1
Mercerisation, loss per cent.	7·5	13·2	10·3	8·5
Acid purification, loss per cent.	1·8	1·9	3·3	2·0
Nitration, gain per cent.	23·6	32·2	27·0	36·7
Cellulose, per cent. ...	77·4	79·3	76·2	77·7
Length of ultimate fibre.	1·7–3·0 mm. or 0·07–0·12 in.	2·0–2·5 mm. or 0·08–0·10 in.	1·5–2·6 mm. or 0·06–0·10 in.	1·5–3·0 mm. or 0·06–0·12 in.

On comparing these figures it is evident that the quality of the present specimen is not inferior to that of the Indian samples, and in some respects it is, in fact, superior, notably in the greater resistance of the fibre to the action of alkali as indicated by the

results of the hydrolysis and mercerisation. It is also evident that this material resembles jute in its chemical behaviour and composition, and also in the length of its ultimate fibres.

Fibre of *Triumfetta rhomboidea* ("Nzonogwe" fibre).

This sample consisted of about 1½ lb. of prepared fibre and ½ lb. of the dried bark in ribbons of a length of 4½-5 feet.

The prepared fibre resembled that of the "Denje" plant in general character and appearance. It was imperfectly cleaned, and from 4½-5 feet long. On chemical examination it yielded the following results, to which are added for comparison those given by a sample of Indian jute of "extra fine" quality.

—	*Triumfetta rhomboidea* ("Nzonogwe").	"Extra fine" Indian jute.
Moisture, per cent.	10·4	9·6
Ash, per cent.	0·6	0·7
α-Hydrolysis, loss per cent.	9·1	9·1
β-Hydrolysis, loss per cent.	14·7	13·1
Mercerisation, loss per cent.	8·5	8·5
Acid purification, loss per cent.	3·4	2·0
Nitration, gain per cent.	30·2	36·7
Cellulose, per cent.	76·2	77·7
Length of ultimate fibre	2·0-2·8 mm. or 0·08-0·11 in.	1·5-3·0 mm. or 0·06-0·12 in.

These results show that this fibre is of good quality, and closely resembles jute in its chemical characteristics and composition, as well as in the length of its ultimate fibres.

Representative specimens of "Denje" and "Nzonogwe" fibres were submitted to fibre experts and brokers for commercial valuation. They reported that the products were similar in character, and both consisted of soft, fine bast fibre. The strength was mixed—a small portion of each being fairly strong, but the greater part weak. The fibres were probably inferior to jute in spinning qualities, and were apparently only suitable for tow yarns. The brokers stated that the value of the fibres was approximately £12 per ton, but that a higher price might be obtained if they were found to give good results when worked with machinery. It was considered desirable that a larger quantity of the fibres should be examined with special reference to their behaviour in spinning and other manufacturing processes, and it was suggested that a ton or two of each fibre, as clean as possible, should be sent for this purpose. Full particulars were requested as to the possibilities of supply, and the price at which the fibres could be delivered in London, in order that manufacturers might be induced to make trials of these products.

From the foregoing reports it appears that these fibres, if carefully prepared, might prove to be of commercial value if constant supplies could be assured. It has, however, to be remembered

that these fibres would have to compete with jute, which has already a regular and well-established market.

In accordance with the suggestion that a ton or two of each of these fibres should be sent to the Imperial Institute for examination with special reference to their behaviour in spinning and other manufacturing processes, a bale of "Denje" fibre, and two bales of "Denje" and "Nzonogwe" fibres mixed, were consigned to the Crown Agents for the Colonies by the British Central Africa Government. Small samples were also forwarded direct to the Imperial Institute by parcel post.

The sample of "Denje" fibre received consisted of ribbons averaging 4 feet in length, and varying between 3 feet 3 inches and 5 feet. The ribbons were somewhat lustrous, and varied in colour from pale grey to buff. The fibre was of fair strength and fairly well cleaned.

The results of the chemical examination of this sample compare unfavourably with those obtained for the sample previously received. The figures relating to a sample of "extra fine" Indian jute examined at the Imperial Institute are added for comparison.

—	Present sample.	Previous sample.	Extra fine Indian jute.
	Per cent.	Per cent.	Per cent.
Moisture	9·0	10·3	9·6
Ash	1·1	1·0	0·7
α-Hydrolysis (loss)	12·0	8·5	9·1
β-Hydrolysis (loss)	20·0	13·5	13·1
Acid purification (loss) ...	8·8	1·8	2·0
Cellulose	73·3	77·4	77·7

The unfavourable results are accounted for by the imperfect cleaning and preparation of the present sample as compared with the previous one. If well prepared this fibre would be of more value as a substitute for jute.

None of the samples taken from the bales was so well cleaned and prepared as this preliminary sample.

Bale No. 1, "Denje," consisted of harsh and gummy fibre varying in colour from pale buff to brown and of slight lustre. The length was 3 to 4 feet, some shorter fibre being present.

Bale No. 3 was said to be "Denje" and "Nzonogwe" fibres mixed. The fibre resembled No. 1, but was darker in colour, more gummy, and not so well prepared. The length was 3 to 4 feet, with some shorter fibre, and also a little measuring about 5 feet.

Bale No. 4 also appeared to consist of "Denje" and "Nzonogwe" fibres mixed. The fibre resembled that contained in bale No. 1, but was perhaps rather softer. The length was 3 to 4 feet, but some longer fibre was also present.

The three bales of "Denje" and "Nzonogwe" fibres were sent for trial to a firm of jute spinners in Dundee, who reported

that it was impossible to differentiate between them. The fibre was insufficiently retted, and six weeks' treatment in the "batch" was necessary before spinning could be attempted.

The yarn which was obtained was a good level thread but harsh. Very little moisture was retained, although a large quantity was used in the preparatory stages. There was also an absence of the floss which is present on jute yarns. In strength the yarn was weaker than jute yarn of corresponding size. This, however, was probably due to the long time during which the fibre was soaking in the "batch."

The spinners stated that it was exceedingly difficult to give a valuation for the fibre, but they classed it as about equal to the bottom number of an ordinary Bengal jute mark. In the state in which it was received the material was valued at £16 per ton, but it would no doubt be worth much more if properly retted.

The spinners were of opinion that with more experience in retting, which is the most important process in the preparation of fibres of this class, the producers would be able to obtain a much improved fibre. They were also under the impression, though not certain on the point, that the plants had been allowed to get too old before the fibre was collected, and that consequently the gum had become very hard.

Transvaal.

Sida species.

Two samples of the fibre of a species of *Sida*, probably a variety or form of *Sida rhombifolia*, received from the Transvaal in 1905, were examined in the Scientific and Technical Department of the Imperial Institute. The product had not been very well cleaned and prepared and contained a certain amount of gummy impurity. The colour of the fibre varied from brown to pale grey, and the length from about 5 feet to 7 feet.

Commercial experts to whom the specimens were submitted reported that the fibre was of fair colour and good length; and, if found suitable for spinning with jute machinery, would probably be worth from £14 to £17 per ton.

It was suggested that a consignment of the carefully cleaned fibre should be forwarded for the practical determination of its spinning qualities by manufacturers.

West Africa.

Hibiscus esculentus.

Hibiscus esculentus is the well-known "Okra," "Awkraw," or "Bhindi" which yields a mucilaginous seed-pod used in many parts of the world as a vegetable, and appears to be grown in all parts of West Africa.

Sierra Leone.—A sample of "Awkraw" fibre was forwarded from Sierra Leone in 1905. The material was of a pale straw colour, fairly lustrous, but not well cleaned, somewhat harsher

than jute, and about $3\frac{1}{2}$ to 4 feet long. The results of the chemical examination of this fibre are given in the following table, to which are added the results obtained with a specimen of "extra fine" Indian jute:—

	"Awkraw" Fibre. Per cent.	"Extra fine" Indian Jute. Per cent.
Moisture	10·5	9·6
Ash	1·1	0·7
α-Hydrolysis (loss) ...	13·4	9·1
β-Hydrolysis (loss) ...	17·7	13·1
Cellulose	77·2	77·7
Length of the ultimate fibres.	1·2-3·1 mm. or 0·05-0·12 inch.	1·5-3·0 mm. or 0·06-0·12 inch.

These figures indicate that "Awkraw" fibre is of a somewhat different character from Indian jute, and is much more susceptible to the attack of alkali (as shown by the hydrolysis) and on this account would probably be somewhat less durable.

Commercial experts reported that this fibre could be spun with good results when mixed with jute, and if of somewhat greater strength would be worth from £18 to £20 per ton (with jute at from £16 to £25 per ton) and would no doubt find a ready sale.

A second sample of the fibre, described as "Okra" fibre, was sent from Sierra Leone for further investigation in 1906. This sample was obtained from the plants after the second series of fruits had been gathered, in order to test the value of the fibre prepared at this particular stage. The fibre was mostly from 2 feet to 2 feet 8 inches long, but some short strands about 18 inches in length were also present. In general the product resembled the previous sample of "Awkraw" fibre, but was softer, whiter, and more lustrous, though only about two-thirds the length. The strength was uneven and poor. The quantity of the fibre supplied was insufficient for chemical examination.

Commercial experts, to whom the sample was submitted, described it as a brittle, jute-like fibre which, though of good colour, was mostly tender and weak. Its value was considered doubtful, but probably from £20 to £22 per ton. At the time of this valuation jute prices were much above the average, and, under ordinary conditions, this sample would not have been worth more than about £15 per ton. As a sample of fibre prepared from the older plants was valued at £18 to £20 per ton when prices were normal, it appeared that in spite of the better appearance of the sample under consideration, its value would be less on account of its inferior length and poor strength. It is, however, unsafe to draw a general conclusion as to the best period for the extraction of fibre from the plant from the examination of a single sample.

Another specimen of "Okra" fibre received from Sierra Leone was well cleaned, soft, nearly white, lustrous, and of fairly good strength. It was about five feet long, and on chemical examination gave the following results:—

	Per cent.
Moisture	10·6
Ash	0·2
a-Hydrolysis (loss)	8·8
β-Hydrolysis (loss)	14·0
Acid purification (loss)	0·9
Cellulose	72·4

The fibre compared favourably with the sample examined in 1905. The proportion of cellulose was lower, but the comparatively small losses on hydrolysis showed that the fibre was likely to resist the action of water satisfactorily. This product was well grown and beautifully prepared; it was valued at £20 per ton (with "medium" jute at £15-£17 per ton), and was said to be readily saleable in large quantities. This sample of fibre was prepared from "Okra" plants cut after the first crop of fruits had been gathered; it was pointed out that it would be necessary to examine specimens, prepared at different stages of growth, before the best period for cutting the plants for the production of fibre could be determined.

Southern Nigeria.—A sample of the fibre of *Hibiscus esculentus* from Southern Nigeria was of uneven quality. The best portion was almost white, lustrous, rather harsh and not very well cleaned and prepared; the remainder was of darker colour and of irregular staple. The product was valued at £18 per ton (with "medium" jute at £23-£25). The harshness of the fibre suggested that it had been prepared from old plants, and it had evidently been insufficiently retted.

Hibiscus lasiocarpus (?).

Sierra Leone.—A fibre of the jute class sent from Sierra Leone for examination was possibly derived from *Hibiscus lasiocarpus*, and consisted of ribbons of fibre which appeared to have been stripped from the bark, but to have undergone little or no further preparation. The product was of mixed and uneven character, some of the strips being coarse and gummy, whilst others were fine and silky. The fibre was of a pale buff colour with slight lustre, and was of fair strength and irregular length, varying from 3 feet to 5 feet 8 inches. It was stated that the plant yielding this product is found in all parts of the Colony, and that the fibre is extensively used for making ropes, baskets, &c.

A specimen of the fibre, cleaned as far as possible by hackling, was submitted to chemical examination and furnished the results given in the following table, to which are added, for convenience of comparison, those yielded by a sample of *Hibiscus cannabinus* fibre from Madras:—

	Hibiscus species, Sample No. 2, from Sierra Leone Per cent.	*Hibiscus cannabinus* from Madras. Per cent.
Moisture	9·2	10·1
Ash	0·7	2·0
α-Hydrolysis (loss)	12·5	8·8
β-Hydrolysis (loss)	17·5	13·7
Acid purification (loss)	3·1	2·5
Cellulose	75·7	74·8
Length of ultimate fibre	2·1-3·05 mm. or 0·08-0·12 in.	1·5-4·0 mm. or 0·06-0·16 in.
Length of staple...	3 ft. to 5 ft. 8 in.	Average 7 ft.

These results show that this sample resembles the *Hibiscus cannabinus* fibre in general composition, but suffers a greater loss on hydrolysis, probably due to the fact that it has not been carefully cleaned and prepared.

The commercial experts reported that the fibre was of fair length and strength and of good colour, and that if the material were shipped in quantities of 20 to 50 tons at a time, it would sell freely at £15 to £16 per ton (February, 1906).

The fibre is somewhat similar to jute, and there can be no doubt that its value for spinning purposes could be much enhanced by the exercise of greater care in its preparation.

Hibiscus lunariifolius.

Northern Nigeria.—A sample of "Ramma" fibre from Northern Nigeria consisted of brownish-white fibre which was on the whole well prepared, but insufficiently cleaned in parts. The product possessed good lustre and strength and varied in length from 3 to 7 feet. On chemical examination it yielded the following results:—

	Per cent.
Moisture	8·5
Ash	0·4
α-Hydrolysis (loss)	7·4
β-Hydrolysis (loss)	10·2
Acid purification (loss)	0·4
Cellulose	76·8

The fibre suffered comparatively small loss on hydrolysis, and would therefore resist the prolonged action of water. The product was too harsh for use as a jute substitute, but would make strong and durable ropes. It was regarded by experts as worth about £12 per ton (with "common" jute at £11-£12 per ton).

A specimen of brown ribbons of "Ramma" bark was received from Northern Nigeria at a later date. These ribbons were tough and gummy, and about 6 feet long. In this condition the product could only be used as a paper material and would probably be worth about £4 per ton. It was suggested that experiments should be made to prepare the fibre by retting the stems in a similar manner to that employed in the extraction of jute.

Southern Nigeria.—A specimen of "Ramo" fibre, supposed to have been derived from *Hibiscus lunariifolius*, was forwarded from Olokomeji in 1907. The material consisted of well cleaned and nearly white fibre of good lustre, but containing a small quantity of barky matter. The fibre was of fair strength, but harsher than jute and somewhat frayed. Its length varied up to about 7 feet.

The results of the chemical examination of this sample are given in the following table, and are compared with those furnished by specimens of *Hibiscus cannabinus* from Madras and Indian jute of "extra fine" quality:—

—	Present sample.	*Hibiscus cannabinus* from Madras.	"Extra fine" Indian jute.
	Per cent.	Per cent.	Per cent.
Moisture	11·5	10·1	9·6
Ash	0·7	2·0	0·7
α-Hydrolysis (loss)	8·4	8·8	9·1
β-Hydrolysis (loss)	10·0	13·7	13·1
Acid purification (loss) ...	0·9	2·5	2·0
Cellulose	77·5	74·8	77·7

The fibre was of excellent length and quality. The loss on hydrolysis was low, and the proportion of cellulose nearly as great as in "extra fine" Indian jute. In both these respects the "Ramo" fibre was superior to the sample of *Hibiscus cannabinus* from Madras. The fibre would prove valuable as a jute substitute, and would be saleable in large quantities at £17 per ton (with "medium" jute at £15-£17 per ton). The presence of knots in the fibre, caused by the branching of the stem, was noticed, and it was suggested that this defect could be obviated by sowing more thickly.

Hibiscus quinquelobus.

Sierra Leone.—This plant is known in Sierra Leone as "Kowe" or "Corwey" in Mendi, and "Nassim" in Timani, and is sometimes referred to as "West African jute." Owing to the facility with which this fibre can be prepared, it has received special attention, and two Government agents have endeavoured to encourage its production. A small export trade in this fibre is being developed, but it is not possible that a large industry can be established unless the plant is systematically cultivated. Experiments on the cultivation of this species have been conducted at Mabang.

The first sample of the fibre submitted to the Imperial Institute consisted of well-cleaned bast ribbons of fair strength. The length of the fibre varied from 3 feet to 7 feet 9 inches, most of it being about 5 feet long. The fibre was of a pale buff colour

of fair lustre, fine, and fairly soft. On chemical examination it yielded the following results:—

	Per cent.
Moisture	9·8
Ash	0·45
α-Hydrolysis (loss)	7·9
β-Hydrolysis (loss)	11·0
Acid purification (loss)	1·1
Cellulose	76·3
Length of ultimate fibre	1·0-3·2 mm. or 0·04-0·13 in.

On comparing these figures with those furnished by a sample of Indian jute of "extra fine" quality (see page 39), it is evident that the "Correy" fibre is of good quality, and resembles jute in its composition and behaviour.

The commercial experts to whom the sample was referred classed the material as a strong, bast-like fibre of good colour, and worth £25 to £26 per ton (June, 1906).

A consignment of about one ton of "Kowe" fibre (*Hibiscus quinquelobus*) was forwarded to the Imperial Institute in April, 1907. The product consisted of brownish-white ribbons composed of interlacing fibres which were slightly lustrous, well cleaned, rather harsh, of fair but uneven strength, and irregular length varying from 3 feet 6 inches to 6 feet. On chemical examination it furnished the following results:—

	Per cent.
Moisture	11·5
Ash	0·2
α-Hydrolysis (loss)	6·0
β-Hydrolysis (loss)	8·5
Acid purification (loss)	0·2
Cellulose	78·0

These figures show that in chemical composition and behaviour the sample was very similar to the "Kowe" fibre examined previously. The loss on hydrolysis was unusually low and indicated that the fibre would prove durable. The product was sold at public auction in London, with the result that a portion of the material realised £18 per ton, whilst the remainder sold at £17 5s. per ton. The brokers who sold the consignment reported that £18 per ton was about the price, subject to market fluctuations, which might be expected for future lots of this fibre, for which it seemed possible that a demand might be created. They suggested that five tons of the fibre should be regularly placed on the market every month as a beginning.

Honckenya ficifolia.

Honckenya ficifolia grows abundantly in the swamps of the Sierra Leone Protectorate, and would yield a perpetual supply of stalks for retting if care were taken in cutting it. It is known by

the various names of " Napunti " (Timani), " Potepo " (Mendi), and " Bolo-bolo " (Yoruba).

Attention was directed to the fibre of this plant as long ago as 1888, when a sample, accompanied by botanical specimens, was forwarded from Lagos through the Colonial Office to the Royal Gardens, Kew. The fibre was reported by commercial experts to belong to the jute class, to be superior to jute in strength, and to be readily saleable, and worth at that time £16 per ton (*Kew Bulletin*, 1889, 15).

Sierra Leone.—The preparation of this fibre has been made the subject of investigation by Government agents in Sierra Leone, who have reported that considerable difficulty is experienced in separating the outer bark from the inner fibrous layer, and that this is particularly marked in the case of the older plants. Experiments are in progress with a view to ascertain whether the fibre can be more successfully extracted from young plants.

The first sample of fibre forwarded to the Imperial Institute from Sierra Leone consisted of uncombed bast ribbons, which varied in length from 4 to 10 feet, the greater part being from 6 to 10 feet long. The fibre was well cleaned and prepared, but was of poor strength, and varied in colour from white to brown.

On chemical examination the material furnished the following results:—

	Per cent.
Moisture	9·6
Ash	0·3
α-Hydrolysis (loss)	6·0
β-Hydrolysis (loss)	9·7
Acid purification (loss)	0·4
Cellulose	78·3
Length of ultimate fibre	2·0-3·6 mm. or 0·08-0·14 in.

These figures show that the " Napunti " fibre closely resembles Indian jute in its chemical character, and is nearly as rich in cellulose as " extra fine " quality Indian jute (compare page 39). It suffers a comparatively small loss on hydrolysis, and should consequently prove very resistant to the prolonged action of water.

The product was described by experts as a jute-like fibre of mixed colour; value, about £20 per ton (June, 1906).

A sample of " Napunti " fibre collected from young plants of the first year's growth, before they had flowered, consisted of soft, fine, greyish fibre of rather poor lustre, and had been well cleaned but probably over-retted, as its strength was very poor. It was from 3 feet to 3 feet 6 inches in length, and was regarded as worth about £20 per ton (with " medium " jute at £22-£25 per ton, and " common " jute at £18 10s.-£20 per ton).

Two other samples, which were collected from old plants after flowering, were of little value, as they consisted of ribbons and tended to split up into short pieces on combing.

In connection with another sample of "Napunti" fibre, it was stated that the material represented the only form in which the natives could prepare this fibre, and it was consequently desired to ascertain whether it would have any commercial value. It was thought that the natives could make a profit from the sale of such fibre at ½d. per lb. or even less.

The sample consisted of a large bale of coarse, brown, fibrous, bast ribbons, which were woody and gummy. The length of the ribbons was from 3 to 4 feet.

Chemical examination of the material gave the following results:—

Moisture	... ...	9·0 per cent.
Ash ...	... ...	4·0 ,, ,, on dry material.
Cellulose	... ...	55·0 ,, ,, ,, ,,
Length of ultimate fibre	... ...	1·4 mm. to 3·0 mm. (mean 2·1 mm.) or 0·056 to 0·12 in. (mean 0·08 in.).

The fibre in this form appeared to be only suitable for use as a paper-making material, and the results of the chemical examination showed that the ribbons contained about the same percentage of cellulose as esparto grass.

Owing to the bulky nature of the "Napunti" ribbons, it seemed doubtful whether the exportation of the fibre in this form would be remunerative in view of the cost of transport.

A sample of the ribbons was submitted to a paper expert for an opinion regarding the suitability of the material for paper-making. He reported that it could be used for the manufacture of paper, but that he could not recommend bringing the raw material to England. It would be better, he thought, to consider the advisability of treating the material before shipment and reducing it to a condition of unbleached "half-stuff," leaving the paper-maker to bleach it as required. In the expert's opinion the unbleached "half-stuff" would probably fetch from £7 to £8 per ton if sold in sufficient quantity of uniform quality.

Special experiments, however, proved that the "Napunti" ribbons as received yielded 47·3 per. cent of air-dry "half-stuff," containing 8 per cent. of moisture. Consequently over two tons of ribbons would be required to furnish one ton of "half-stuff."

In view of these results it was considered extremely doubtful whether the course suggested by the expert would be remunerative. The cost of preparing the crude ribbons was given as ½d. per lb. (£4 13s. 4d. per ton) or even less, and as the material yields less than half its weight of "half-stuff" valued at £7 to £8 per ton, there would be no margin for expense, freight and profit.

It therefore appeared that unless the cost of production of the "Napunti" ribbons could be greatly reduced there would not be much chance of utilising the fibre for paper-making.

Gold Coast.—Reference may be made here to a sample of this fibre ("Bolobolo" fibre) which was forwarded to the Imperial Institute from the Gold Coast in 1905. This product was much inferior to the well-prepared material from Sierra Leone, owing chiefly to its having been very imperfectly cleaned. Commercial experts to whom it was submitted stated that it was weak and of very little value.

"Borfroko" or "Abala" Fibre.

Sierra Leone.—The plant yielding this fibre is at present unidentified. The sample submitted from Sierra Leone consisted of well-cleaned fibre which showed considerable variation in colour, texture, length, and general appearance. The colour ranged from white to reddish-brown, and whilst some of the fibre was quite soft, other portions were harsh. The length varied from 10 inches to 6 feet, but most of the fibre was 3 feet to 3 feet 4 inches long. Chemical examination of the product furnished the following results:—

	Per cent.
Moisture	9·6
Ash	0·4
a-Hydrolysis (loss)	9·3
β-Hydrolysis (loss)	14·4
Acid purification (loss)	1·0
Cellulose	76·3
Length of ultimate fibre	1·0-3·6 mm. or 0·04-0·14 in.

These results show that the fibre is a member of the jute class, and resembles the "Napunti" and "Corwey" fibres so far as chemical behaviour and composition are concerned, although it loses more than these do on hydrolysis and is not quite so rich in cellulose as the "Napunti" fibre. It is, moreover, inferior to "Napunti" and "Corwey" fibres on account of its variation in colour, length, and texture.

The commercial experts reported that this was a rather short, mixed, bast fibre, part of the sample being weak; value, £17 to £18 per ton (June, 1906).

The valuation given for this fibre is based on the belief that it would be possible to utilise it as a jute substitute, but its value could only be determined definitely by technical trials on a manufacturing scale in comparison with jute.

Triumfetta cordifolia var. *Hollandii.*

Gold Coast.—This was a specimen of soft, well-cleaned fibre, of pale buff colour, good lustre, fine and even diameter, and good strength. It was 5 feet long.

When submitted to chemical examination it gave the following results:—

	Per cent.
Moisture	10·3
Ash	0·8
α-Hydrolysis (loss)	7·3
β-Hydrolysis (loss)	10·4
Acid purification (loss)	0·6
Cellulose	73·5
Length of ultimate fibre	1·0-3·5 mm. or 0·04-0·14 in.

These results show that the fibre is somewhat similar to that of *Triumfetta rhomboidea*. It could be used for the same purposes as jute. The loss on hydrolysis is less than that found for a sample of "extra fine" Indian jute, but on the other hand the percentage of cellulose is lower (see page 39). The fibre was regarded by commercial experts as worth £35 per ton (with finest Bengal jute at £35 to £40 per ton).

Urena lobata.

Urena lobata occurs in India, the United States, South America, Africa and other tropical countries. The fibre would probably be a good jute substitute. The plant known in West Africa as "Na fen fe" (Timani), "Subwe" (Mendi), and "Bolobolo" (Yoruba). Apparently some confusion exists with regard to the last name, which is said to be applied also to *Honckenya ficifolia*. *Urena lobata* occurs everywhere along the West African coast, but is extremely variable in the form of its leaves. Good specimens of fibre have been prepared in Sierra Leone, but the plant growing there does not form long, straight stems, and the fibre is therefore rather short.

This fibre is known in Brazil as "Aramina." A description of the product is given on page 45.

Gambia.—A sample of this fibre received from the Gambia was soft, of a greenish-grey colour, well cleaned and prepared, fine, lustrous, of good strength and about 3 feet long. On chemical examination it gave the following results:—

	Per cent.
Moisture	10·9
Ash	0·4
α-Hydrolysis (loss)	9·8
β-Hydrolysis (loss)	16·3
Acid purification (loss)	1·3
Cellulose	74·6

In chemical composition and behaviour the fibre was superior to a specimen of "medium quality" Indian jute with which it was compared. It was only half the usual length of jute, but would nevertheless be readily saleable as a jute substitute at £17 per ton (with "medium" jute at £15-£17 per ton). It was

suggested that a consignment of the well-prepared product should be forwarded for trial sale.

A specimen of the fibre of a species of *Urena* has also been received from India, and is described below.

INDIA.

Urena species.

A small sample of the fibre of a species of *Urena*, grown at Nettigandi, consisted of a somewhat harsh, greyish fibre which had not been completely extracted but was gummy, and in parts woody. The strength was uneven, but very fair on the whole. The fibre was of irregular length with an average of about 4 feet. The product was regarded by commercial experts as worth from £12 10s. to £13 per ton for spinning in admixture with jute (when "medium" jute was quoted at £15-£17 per ton). The fibre was obviously insufficiently retted. It resembled the "Aramina" fibre from Brazil (see below), and was decidedly harsher than jute. It was pointed out that a softer and better product could no doubt be obtained by more careful retting, and it was also suggested that attention should be directed to obtaining the fibre of good and regular length.

A specimen of the fibre of *Urena lobata* has been received from the Gambia, and is described on page 44.

BRAZIL.

Urena lobata and U. sinuata.

A sample of "Aramina" fibre was forwarded in 1900 by H.M. Consul-General at Rio de Janeiro, and was examined in the Scientific and Technical Department of the Imperial Institute. In a report on the results of this inquiry (Technical Reports and Scientific Papers, Imperial Institute, 1903, page 108), it was stated that the fibre resembled jute of the best quality, and could be employed for the same purposes. In order to determine the value of this product more precisely, it was considered necessary that a large consignment of the prepared fibre should be examined with special reference to its behaviour in manufacturing processes, and it was suggested that a further supply of 1 or 2 cwts. of the material should be collected and forwarded for this purpose.

In response to this suggestion, further samples were forwarded in October, 1903, together with a memorandum describing them and giving certain information regarding the cultivation of the plant in Brazil and the extraction and utilisation of the fibre.

The samples were as follows:—

No. 1. Stems of Aramina "Carapicho" (*Urena sinuata*).
No. 2. Stems of Aramina "Guaxima" (*Urena lobata*).

Unfortunately, these samples did not consist of the prepared fibre which was required for the practical tests mentioned above, but of the hard dry stems. Inquiries were made as to the possibility of extracting the fibre from this material, but it was found

that this could not be done in this country. It was therefore impossible to carry out the practical trials.

No. 3. Stripped bark of the "Carapicho" variety.

This specimen was of interest as illustrating the preparation of the fibre.

No. 4. Prepared fibre of the "Guaxima" variety.

This sample consisted of strong, fine, lustrous fibre of a pale buff colour, deeper in some parts than others. The length of its staple varied from 4 to 5 feet. The results of its chemical examination are given in the following table, which also contains for convenience of comparison those obtained with the sample of Aramina fibre previously examined and the results furnished by a specimen of Indian jute of good quality:—

—	Aramina fibre.		Indian jute of "extra fine" quality.
	Present sample.	Previous sample.	
	Per cent.	Per cent.	Per cent.
Moisture	9·3	13·4	9·6
Ash	0·7	—	0·7
α-Hydrolysis (loss)...	10·2	17·7	9·1
β-Hydrolysis (loss)...	18·2	—	13·1
Acid purification (loss)	1·9	2·5	2·0
Nitration (gain)	42·0	35·7	36·7
Cellulose	76·0	75·7	77·7
Length of ultimate fibre ... mm.	1·5–2·2	1·5–3·5	—

These results indicate that this sample of Aramina fibre was of somewhat better and more durable quality than that previously examined, and closely resembled jute in its chemical behaviour and composition. Its superiority to the previous sample is shown particularly by the lower loss sustained on α-hydrolysis and the greater increase of weight on nitration.

The examination of this second specimen of Aramina fibre confirmed, therefore, the opinion expressed in the former report that this product was of excellent quality and likely to prove of considerable commercial value.

No. 5. Seeds of the "Carapicho" variety.

This specimen was principally of botanical interest.

No. 6. A small piece of sacking cloth made from Aramina yarn. This was of a good, useful character.

Specimens of the fibre of species of *Urena* from India and the Gambia are described on pages 44 and 45.

"Carupacho Manado."

A sample of fibre, of unknown botanical origin, forwarded for examination from Brazil, and labelled "Carupacho Manado, No. I. type," consisted of well cleaned, lustrous, greyish fibre, of character resembling that of jute but somewhat harsher. The

On chemical examination it gave results which approximated to those yielded by a sample of "extra fine" Indian jute (see page 46). The fibre was, however, less resistant to the action of hot dilute alkali, and contained a somewhat smaller proportion of cellulose than the Indian jute, and might, therefore, prove rather less durable. The length of the ultimate fibres was 1·1-4·4 mm., with an average of 2·7 mm. (or 0·04-0·18 inch, with an average of 0·11 inch), which is practically identical with that of the ultimate fibres of jute. The grey colour of the sample may have been caused by the use of dirty water for retting. A lighter-coloured fibre would doubtless be of greater value.

Commercial experts reported that the fibre was of the nature of jute, would be suitable for use in conjunction with Bengal jute, and would certainly be of interest to spinners. The fibre was regarded as worth from £15 to £15 10s. per ton (with "medium" jute at £15-£17 per ton) and would be readily saleable.

OTHER TEXTILE FIBRES.

The fibres reported on in this section have been suggested as materials which might possibly be utilised in the manufacture of textiles, and comprise "Buazé" fibre (*Securidaca longepedunculata*) from Nyasaland, pineapple fibre (*Ananas sativus*) from Southern Rhodesia and the Gold Coast, fibres of the "gift-bol" (*Buphane disticha*) and *Asclepias fruticosa* from the Transvaal, fibres of *Marsdenia tenacissima*, *Cryptostegia grandiflora*, and *Girardinia heterophylla* from India, a fibre of unknown botanical origin from Southern Nigeria, and a palm fibre, termed "vegetable wool," from Paraguay.

NYASALAND.

Securidaca longepedunculata.

Attention was first drawn to the fibre of *Securidaca longepedunculata*, known as "Buazé" fibre, by Dr. Livingstone, in 1857. A sample was submitted to commercial experts, who reported that the fibre resembled flax worth £50 to £60 per ton, but that no positive statement as to its value could be made until sufficient material had been received to enable spinning trials to be carried out. (Compare *Kew Bulletin*, 1889, 222-225.)

The possibilities of the commercial utilisation of Buazé fibre, however, received no further consideration until, at the end of the year 1905, a small bale of the material and a further small sample were received at the Imperial Institute from Nyasaland.

Description of Samples.—The small sample of fibre was labelled as follows:—"British Central Africa. Buazé fibre, *Securidaca longepedunculata*. As collected and prepared by natives, Zomba, April to June, 1905."

The fibre was from 1 foot 5 inches to 2 feet 2 inches in length, and of a yellowish colour. It was badly cleaned and prepared, many of the fibres being still gummed together. When clean, the fibre was strong, fine and flax-like.

The fibre in the bale was, on the whole, not so well prepared as the small sample, and was of a very mixed character, much of the material consisting merely of strips of bark. A further description is given under the heading "Technical Examination."

Chemical Examination.—The following are the results of the chemical examination of the fibre. The small sample was insufficient for complete examination, and therefore a quantity of similar fibre was selected from the bale for the purpose:—

	Small Sample. Per cent.	Sample taken from bale. Per cent.
Moisture	6·7	6·5
Ash	1·8	1·8
α-Hydrolysis (loss)	—	18·8
β-Hydrolysis (loss)	—	23·5
Acid purification (loss)	—	11·5
Nitration (gain)	42·0	43·3
Cellulose	69·2	74·5

Length of ultimate fibre ... ... { *0·6 to 1·5 inch; mean 0·9 inch.*

The fibre, although badly cleaned, as shown by the large loss on acid purification, contained a fair percentage of cellulose, and did not suffer great loss on hydrolysis. It was not lignified.

Technical Examination.—Two kinds of material were present in the large sample submitted for examination.

The first was a coarse fibre obtained from the bark of the thick stems, whilst the second consisted of strips of bark apparently derived from the thinner twigs.

The coarse fibre was very short, but might be utilised for the manufacture of rough bags; its commercial value would, however, be low.

The strips of bark from the thin twigs were subjected to a retting process, and the fibre thereby obtained was found to be of good lustre and strength and of satisfactory colour. On account of the much-branched character of the twigs—a serious defect—the fibres were much reduced in length during this operation.

The fibre obtained from the thin twigs could probably be utilised as a textile material, but further experiments will be necessary as to the best methods of extracting the fibre from the bark. It seems likely that the best results would be obtained by scraping the thin bark on the spot before the plant juices have dried on the fibre; the scraped fibre could be degummed later.

It was found from laboratory experiments that the bark from the twigs yielded about 37 per cent. of clean fibre.

A representative specimen of the fibre from the bale was submitted to a commercial expert, who stated that "in the condition in which it was received it was of very little practical

value. He also pointed out that the irregularity in the length of the fibre was a bad feature of the material, which would result in much waste in the process of retting.

A sample of the prepared fibre, which had been retted at the Imperial Institute, was also forwarded to the expert, who reported that if this could be produced sufficiently cheaply it might be used in the place of flax tow, which is at present quoted at about £30 per ton.

The expert carried out a series of experiments on the retting of the fibre, and stated that the gums present were very difficult to soften and remove. The ordinary treatment was found to be useless, and the only method of removing the gums was apparently to scrape them off by hand after the steeping process. This would be an impossible course of procedure unless labour was very plentiful and cheap.

There is no doubt that the Buazé plant contains a large quantity of excellent fibre, which would be of a useful character if suitable means of getting rid of the gums could be found.

Further experiments are being made in retting the fibre. It was suggested that attempts might be made to extract the fibre on the spot from the fresh plants by scraping the bark immediately after its collection, and that results of such experiments should be communicated to the Imperial Institute, together with specimens of the products obtained.

Rhodesia.

Ananas sativus.

Pineapple fibre has long been used in India and China for the manufacture of lines and thread, and as a substitute for silk, and a material for mixing with wool or cotton. Pineapples are grown extensively in Singapore, chiefly for their fruit, but also to some extent for their fibre, which is exported to China. In the Philippines, the fibre is employed for the manufacture of the fabrics termed "piña" and "rengue." It has not yet been produced in quantities sufficient to give it commercial importance.

A sample of pineapple fibre (*Ananas sativus*), forwarded from Southern Rhodesia in 1903, consisted of very fine, white, well-cleaned fibre, of average length, 11 inches. The brokers reported that it was strong, but very short; if, however, the fibre could be obtained of greater length it would probably be worth from £30 to £40 per ton.

Transvaal.

Buphane disticha.

"*Gift-bol*" *Fibre from the Transvaal.*—The so-called "gift-bol" is the large bulb (somewhat resembling a Spanish onion) of *Buphane disticha*, a plant of the natural order *Amaryllidaceæ*, which grows freely in the Transvaal and Orange River Colony.

The plant is particularly adapted to dry districts since it is capable of putting out roots of a great length, and can thus obtain a supply of moisture which would otherwise be denied.

A sample of the bulbs was forwarded to the Imperial Institute from the Transvaal in order that an examination might be made of a peculiar fibre they contain. A specimen of this fibre was extracted from the bulbs, and was found to be white, silky, lustrous, rather weak, and soft and limp to the touch. The individual fibres had a maximum length of 1·5 inches, but generally varied between 0·4 inch and 1·0 inch. Their diameter was found to be about $\frac{1}{10000}$ inch, and the fibre is therefore about eight times as fine as ordinary cotton or four times as fine as silk. The filaments are grouped together in coils or twisted bundles, and these have a diameter varying from $\frac{1}{4000}$ to $\frac{1}{2000}$ inch. On chemical examination the fibre was found to contain 9·4 per cent. of moisture and 70·8 per cent. of cellulose (calculated on the dried material).

The reports of technical and commercial experts to whom specimens of the fibre were submitted confirmed the conclusions arrived at by the Scientific and Technical Department of the Imperial Institute, and may be summarised as follows.

It is improbable that the "gift-bol" fibre could be used for purposes similar to those to which cotton and silk are applied, for owing to the extreme fineness of the fibre, cotton preparing and spinning machinery would be quite unsuitable for dealing with it, whilst the shortness of the fibre would preclude its being worked by "waste-silk" or "spun-silk" machinery. It is possible that, without isolating the individual filaments of the material, the groups of fibres might be spun, but the resulting yarn would be very coarse and could only be used as a substitute for "cotton-waste" yarn or similar materials. It appears, therefore, that this fibre will be of little value as a textile raw material.

Asclepias fruticosa (*Gomphocarpus fruticosus*).

Samples of strips of bark, labelled "Melk Bosch, *Asclepias fruticosa,*" and a small specimen of the extracted fibre, were forwarded from the Transvaal in 1905.

The strips of bark were of a pale yellowish-green colour, and from 18 to 22 inches long. A sample of fibre was extracted from the bark by boiling it with water or very dilute alkali and scraping and washing the product. The material thus obtained consisted of bundles or groups of fibres which had been partially resolved into their ultimate fibres, and was clean, lustrous, fairly soft to the touch, and of a pale greyish colour. The product was of poor strength, and the ultimate fibres were 0·7 to 1·2 inches long, with an average length of 0·9 inch.

On microscopical examination, the fibres were found to be smooth, of even diameter, and to bear transverse markings, and in these respects resembled flax fibre. The diameter varied from $\frac{1}{2250}$ to $\frac{1}{1000}$ inch, with an average of $\frac{1}{1600}$.

A portion of this fibre, prepared in the Scientific and Technical Department, was submitted to chemical examination with the following results:—

	Per cent.
Moisture	6·6
Nitration (gain)	46·2 (calculated on the dried fibre).
Cellulose	84·2 ,, ,, ,,

The fibre, after treatment with chlorine, gave little or no coloration with solution of sodium sulphite, and the nitrated product was nearly white. These facts indicate that the fibre is not lignified but belongs to the pectocellulose class of fibres, of which flax is the most important member. On comparing these results with those yielded by a sample of the fibre of *Asclepias semilunata* from Uganda (page 74), it is evident that the fibres are very similar in composition:—

	Asclepias fruticosa.	*Asclepias semilunata.*
	Per cent.	Per cent.
Moisture	6·6	7·7
Nitration (gain)	46·2	46·9
Cellulose	84·2	80·4

Both fibres contain a very large proportion of cellulose, and undergo a considerable increase of weight on nitration.

The small specimen of extracted fibre, which accompanied the strips of bark, was white, lustrous, and flax-like. The material resembled the fibre of *Asclepias semilunata* of Uganda, which has been already alluded to, but was somewhat finer. The fibre was less broken up than the sample prepared in the Scientific and Technical Department, and was very clean, of fair but uneven strength and harsh to the touch. The ultimate fibres were very fine and lustrous.

The fibre of *Asclepias fruticosa* possesses valuable properties, and, if the material could be easily extracted from the bark without sacrificing its length, it could no doubt be spun into a yarn resembling that of flax or of ramie. The richness of the fibre in cellulose and the large increase of weight occasioned by nitration show that the material might possibly be useful for the manufacture of explosives. A series of trials is at present being made with fibres of this type in order to ascertain their suitability for this purpose, and it is not improbable that the present fibre, if obtainable in large quantities, would be particularly serviceable.

Gold Coast.

Ananas sativus.

A sample of pineapple fibre, received from the Gold Coast in 1907, consisted of well-cleaned, soft, white fibre, somewhat lustrous, of even diameter and good strength, and about 3½ feet long.

On chemical examination it furnished the following results:—

	Per cent.
Moisture	9·5
Ash	1·1
α-Hydrolysis (loss)	13·7
β-Hydrolysis (loss)	19·4
Acid purification (loss)	1·7
Cellulose	81·5

This sample did not differ essentially from other specimens of pineapple fibre examined at the Imperial Institute, but the length of staple was perhaps above the average. Pineapple fibre does not come into the English market in regular quantities, but it might possibly be used as a flax substitute. The present specimen was considered as nominally worth £30 per ton.

SOUTHERN NIGERIA.

Native Fibre.

A specimen of the fibrous bark of a plant, which is stated to grow abundantly up the Niger, was forwarded to the Imperial Institute from Southern Nigeria in 1905 together with a sample of cloth woven from the fibre by the natives of Onitsha. The botanical identity of the plant was not known.

The cloth was 40 inches long and 19 inches wide and had a fringe at each end, which had been made by plaiting or knitting the warp material. The warp was found to be composed of the fibre obtained from the bark, whilst the weft consisted of native cotton yarn.

By treating the bark with hot dilute solution of soda a mass of fibres was obtained which varied in length from 0·7 to 1·3 inches and had an average diameter of about 0·00063 inch. The fibre was of fairly regular diameter, and exhibited transverse markings not unlike those present in flax fibre, but in some cases these markings were only faintly developed, and the fibre, therefore, presented a smoother surface. The appearance of the fibre when spun and woven is somewhat similar to that of flax or ramie. Comparative determinations of the strength of the portion of the fibre obtained from the native cloth and that of a standard sample of "middling" American cotton showed that the former was about twice as strong as the latter but was inelastic and brittle.

With regard to the possible commercial application of this fibre, it seems improbable that the material could be produced as cheaply as cotton or flax since, if it were shipped to this country in the same condition as the sample now under consideration, special processes would have to be devised and machinery constructed to extract and prepare the fibre prior to spinning. The fibre is of approximately the same length as cotton, but, as already pointed out, is less elastic and more brittle, and, moreover, does not possess the peculiar spirally twisted structure to which cotton, as a short fibre, owes its spinning qualities. It is uncertain, therefore, whether the fibre would exert a sufficient grip or binding power to allow of the production of a fine yarn.

INDIA.

Marsdenia tenacissima.

A sample of the fibre of *Marsdenia tenacissima*, shown at the Colonial and Indian Exhibition of 1886, was examined by Messrs. Cross & Bevan, who reported that it was of excellent quality, and that in point of fineness and durability it ranked next to Rhea fibre (Report on Indian fibres, p. 33).

Since it appeared desirable to investigate more fully the properties and possible applications of this fibre, the Imperial Institute requested the Reporter on Economic Products to procure a sample for this purpose. Considerable difficulty was experienced in India in collecting an authentic specimen of the fibre, but a sample was eventually forwarded, with the information that the plant is fairly abundant in the Rajmahal Hills, but that the process of extracting the fibre is both tedious and laborious, being mainly carried on by hand-stripping.

The sample consisted of a very strong, fairly white fibre, with a staple of an average length of 12 to 13 inches. The results of its chemical examination are given below, and also those of Messrs. Cross & Bevan, obtained from the former sample:—

	Present Sample. Per cent.	Sample examined by Cross & Bevan. Per cent.
Moisture	7·7	4·5
Ash	1·5	1·5
α-Hydrolysis (loss)	7·8	6·2
β-Hydrolysis (loss)	8·9	10·1
Mercerising (loss)	4·9	4·6
Acid purification (loss) ...	3·5	0·8
Nitration (gain)	53·9	31·0
Cellulose	91·5	88·3
Length of ultimate fibre ...	10-30 mm.	5-20 mm.

The fibre contains little or no lignocellulose; this being shown especially by the absence of colour in the nitration product, and by the fact that when the chlorinated product, obtained in the course of the estimation of cellulose, is treated with sodium sulphite no red coloration is produced. It is exceptionally resistant to the action of alkali as is indicated by the comparatively small losses sustained on hydrolysis and mercerising. The remarkable quality of this fibre is shown also by the unusually high percentage of cellulose and by the large increase of weight on nitration.

The present specimen was of better quality than that examined by Messrs. Cross & Bevan; it was richer in cellulose and showed a much larger increase of weight on nitration, whilst the average length of the ultimate fibre was also somewhat greater.

Representative specimens of the fibre were submitted to two leading firms of fibre brokers for commercial valuation. One firm reported that the fibre, although short, was of great strength and

therefore likely to be of value. It was suggested that sample bales should be sent for trial. The other firm reported that the fibre was very strong but harsh. It was too short for machine spinning, and consequently could only be utilised as tow. The sample was said to be worth from £15 to £18 per ton (of a length of 12 to 15 inches); if, however, the fibre could be sent of a length of 30 to 50 inches, its value would probably be from £35 to £40 per ton (July, 1903).

From the foregoing reports it is seen that the fibre is one which might be of importance, whilst the chemical examination shows that it possesses properties which are considerably above the average of those of ordinary fibres. In view of the results obtained it seems desirable to consider whether experiments in cultivating the plant should be undertaken, as it is understood to be of comparatively rare occurrence in India, and also to determine whether the fibre could be successfully treated by machinery.

Cryptostegia grandiflora.

A sample of the fibre of *Cryptostegia grandiflora* was forwarded to the Imperial Institute for examination by the Agri-Horticultural Society, Teynampett, Madras. It was stated that the plant occurs wild throughout the Teynampett district. The sample was said to have been prepared by steeping the branches in water for three days; the fibre was then easily removed, and was afterwards washed with water.

The sample consisted of a nearly white, fine, strong fibre with a staple of average length, 16-20 inches. In its general character and appearance this fibre resembles that of *Marsdenia tenacissima* (page 53). The results of the chemical examination showed that these fibres are also very similar in their chemical properties and behaviour. The two plants are allied botanically, both being climbing shrubs of the natural order *Asclepiadaceæ.*

The results alluded to are given below together with those obtained in the case of *Marsdenia tenacissima*:—

	Cryptostegia Fibre. Per cent.	Marsdenia Fibre. Per cent.
Moisture	7·9	7·7
Ash	0·95	1·5
α-Hydrolysis (loss)	5·2	7·8
β-Hydrolysis (loss)	9·8	8·9
Mercerisation (loss)	4·3	4·9
Acid purification (loss) ...	1·2	3·5
Nitration (gain)	49·0	53·9
Cellulose	92·0	91·5
Length of ultimate fibre ...	10-60 mm.	10-30 mm.

The fibre contains little or no ligno-cellulose; this is shown especially by the absence of colour in the nitration product, and by the fact that when the chlorinated product, obtained in the course

of the estimation of cellulose, is treated with sodium sulphite, no red coloration is produced. It is exceptionally resistant to the action of alkali, as is indicated by the comparatively small losses sustained on hydrolysis and mercerising. The remarkable quality of the fibre was shown also by the unusually high percentage of cellulose, and by the large increase of weight on nitration. In all these particulars, the fibre of Cryptostegia resembles that of Marsdenia. The ultimate fibre, however, is of greater length than that of Marsdenia, its average length being about 30 mm. (1·2 inches) which is equal to that of flax.

The sample was submitted to leading fibre brokers for commercial valuation, who reported that the fibre was of good quality, and worth about £30 per ton. They were of opinion that the fibre might prove of considerable value, but that its commercial possibilities could only be arrived at by submitting it to manufacturing tests, and they asked to be supplied with two or three bales for this purpose. They pointed out that the fibre should be as long and even as possible, and that the long and short filaments should be kept separate; in the present sample the length was very irregular.

Girardinia heterophylla.

A sample of the fibre of the "Nilgiri nettle" (*Girardinia heterophylla*) was forwarded to the Imperial Institute in 1904 by the Officiating Reporter on Economic Products to the Government of India with a request that the product might be submitted to chemical examination and its commercial value ascertained.

The specimen was labelled "*Girardinia heterophylla*, from Calcutta." The fibre was soft, silky, of good strength, and varied in colour from white to reddish-brown. It somewhat resembled ramie fibre in character, but was coarser and less silky. The ultimate fibres were found to possess the remarkable length of 150-500 mm. (6-20 inches)—a peculiarity which does not appear to have been previously recorded for this fibre.

Owing to the small quantity of material available, a complete chemical examination could not be carried out, but the following determinations were made by the usual methods. The results obtained by Messrs. Cross & Bevan (Report on Indian Fibres and Fibrous Substances, page 9), with a specimen of the fibre exhibited at the Colonial and Indian Exhibition, 1886, are added for comparison.

	Sample No. 22,679 from Calcutta. Per cent.	Sample examined by Messrs. Cross & Bevan. Per cent.
Moisture	7·6	7·3
Ash	2·4	1·5
α-Hydrolysis (loss) ...	3·2	2·5
β-Hydrolysis (loss) ...	5·9	9·7
Acid purification (loss) ...	3·2	2·5
Cellulose	93·7	89·6

therefore likely to be of value. It was suggested that sample bales should be sent for trial. The other firm reported that the fibre was very strong but harsh. It was too short for machine spinning, and consequently could only be utilised as tow. The sample was said to be worth from £15 to £18 per ton (of a length of 12 to 15 inches); if, however, the fibre could be sent of a length of 30 to 50 inches, its value would probably be from £35 to £40 per ton (July, 1903).

From the foregoing reports it is seen that the fibre is one which might be of importance, whilst the chemical examination shows that it possesses properties which are considerably above the average of those of ordinary fibres. In view of the results obtained it seems desirable to consider whether experiments in cultivating the plant should be undertaken, as it is understood to be of comparatively rare occurrence in India, and also to determine whether the fibre could be successfully treated by machinery.

Cryptostegia grandiflora.

A sample of the fibre of *Cryptostegia grandiflora* was forwarded to the Imperial Institute for examination by the Agri-Horticultural Society, Teynampett, Madras. It was stated that the plant occurs wild throughout the Teynampett district. The sample was said to have been prepared by steeping the branches in water for three days; the fibre was then easily removed, and was afterwards washed with water.

The sample consisted of a nearly white, fine, strong fibre with a staple of average length, 16-20 inches. In its general character and appearance this fibre resembles that of *Marsdenia tenacissima* (page 53). The results of the chemical examination showed that these fibres are also very similar in their chemical properties and behaviour. The two plants are allied botanically, both being climbing shrubs of the natural order *Asclepiadaceæ.*

The results alluded to are given below together with those obtained in the case of *Marsdenia tenacissima*:—

	Cryptostegia Fibre. Per cent.	Marsdenia Fibre. Per cent.
Moisture	7·9	7·7
Ash	0·95	1·5
α-Hydrolysis (loss)	5·2	7·8
β-Hydrolysis (loss)	9·8	8·9
Mercerisation (loss)	4·3	4·9
Acid purification (loss) ...	1·2	3·5
Nitration (gain)	49·0	53·9
Cellulose	92·0	91·5
Length of ultimate fibre ...	10-60 mm.	10-30 mm.

The fibre contains little or no ligno-cellulose; this is shown especially by the absence of colour in the nitration product, and by the fact that when the chlorinated product, obtained in the course

by the much greater loss occasioned by hot dilute alkali (α- and β-hydrolysis), the high percentage of ash, and the considerable loss sustained on acid purification. In connection with the last-mentioned value, it is noteworthy that the fibre suffered a loss of 8·1 per cent. when boiled with pure water.

The commercial experts reported that the fibre was brittle, deficient in strength, and would probably lose a good deal as waste in the operation of combing. It was stated that an accurate valuation could not be given until the spinning properties of the fibre had been tested, but that if sent regularly in fair quantities it would probably realise £23-£25 per ton, or even more, in the London market.

In conclusion, it may be pointed out that although the fibre has been termed "vegetable wool," the extremely harsh nature of the material would prevent its employment as a wool substitute. The product would probably be useful for the manufacture of twine or coarse thread, or as a material for matting and carpets.

FIBRES SUITABLE FOR THE MANUFACTURE OF CORDAGE.

The reports included in this section deal with a large number of fibres which are regarded as suitable for rope manufacture. The more important of these are: (1) fibres derived from species of *Musa* (the plantain and banana fibres); (2) Sisal hemp and the fibre of other species of *Agave*; (3) Mauritius hemp (*Furcræa gigantea*) and the fibre of other species of *Furcræa*; and (4) New Zealand hemp (*Phormium tenax*). Among other fibres reported on may be mentioned those of species of *Asclepias*, *Dracæna*, *Hibiscus*, and *Neoglaziovia*.

The plantain and banana fibres are of value as substitutes for Manila hemp which is exported in large quantities from the Philippines. The amount exported to the United Kingdom in 1907 was 52,816 tons, of value £1,708,992. An account of the Manila hemp industry of the Philippines has been given in the *Bulletin of the Imperial Institute* (1904, **2**, 48). Considerable attention has been devoted to plantain and banana fibres in the East Africa Protectorate during the last few years, and many samples have been forwarded to the Imperial Institute for examination (see pages 61-64). Specimens have also been received from Rhodesia (page 78), Southern Nigeria (page 83), the Gold Coast (page 84), and the Straits Settlements (page 103).

Sisal hemp is an important rope fibre which is exported in considerable quantities from Mexico, and in smaller amounts from India, the Bahamas, East Africa, and the West Indies. Short articles on the cultivation of this fibre in Mexico, India, and German East Africa have been published in the *Bulletin of the Imperial Institute* (1903, **1**, 201; 1904, **2**, 260; 1907, **5**, 422). True sisal hemp is derived from *Agave rigida* var. *sisalana*, but similar fibres, although usually of somewhat lower value, are

obtained from other species and varieties of *Agave*. Specimens of these fibres have been forwarded for examination to the Imperial Institute from the East Africa Protectorate (page 64), Southern Rhodesia (page 79), Sierra Leone (page 85), India (page 92), and South Australia (page 105).

The fibres derived from the various species of *Sansevieria* are more or less closely related to sisal hemp in general character. These fibres are known as "bowstring hemp." There is considerable variation in the characters of the fibre from different species, as will be seen from the description of the various specimens reported on. Samples of the fibre of the following species have been examined:—*Sansevieria guineensis* from the Sudan (page 58), East Africa Protectorate (page 65), and Sierra Leone (page 87); *S. cylindrica* from Nyasaland (page 78); *S. Ehrenbergii* from Somaliland (page 60) and the East Africa Protectorate (pages 65-72); *S. aethiopica* from the Transvaal (page 82); *S. sulcata*, *S. Stuckyi*, and *S. Volkensii* from the East Africa Protectorate (pages 68, 72, 73); *S. zeylanica* from the Straits Settlements (page 103) and South Australia (page 105); and unidentified species from the East Africa Protectorate (pages 66-72), Rhodesia page 81), and the Gold Coast (page 89). The preparation of the fibre of *S. Ehrenbergii* is now being carried on in the East Africa Protectorate on a commercial scale. An account of this industry has been given in the *Bulletin of the Imperial Institute* (1907, **5**, 24-31).

Mauritius hemp is a fibre derived from the leaves of *Furcraea gigantea*, the "aloe vert" of Mauritius, and in most respects resembles sisal hemp. The extraction, preparation, and marketing of this fibre is an important industry in Mauritius; the exports for the year 1907 amounted to the value of £63,231. *Furcraea gigantea* is widely distributed and samples of the fibre have been received for examination from the East Africa Protectorate (page 64), Uganda (page 76), Nyasaland (page 77), Southern Rhodesia (page 80), Natal (page 83), St. Helena (page 91), India (pages 94, 99), and South Australia (page 105). A specimen of the fibre of *Furcraea cubensis* from Sierra Leone has also been examined (page 86).

New Zealand hemp, the fibre of *Phormium tenax*, is grown very extensively in New Zealand and is the subject of an important industry, an account of which has been published in the *Bulletin of the Imperial Institute* (1907, **5**, 36-45). During the year 1906, the exports of the fibre (including tow) amounted to 33,299 tons, of value £812,712. At the present time an attempt is being made to establish a New Zealand hemp growing industry in St. Helena. Samples of the fibre forwarded from St. Helena to the Imperial Institute are described on page 91.

SUDAN.

Sansevieria guineensis.

A small sample of the fibre of *Sansevieria guineensis* prepared by natives in the Bahr-el-Ghazal was brought to the Imperial Institute by Mr. Harold Brown, and, as no examination of the fibre from this source appeared to have been made, a preliminary

investigation was carried out. The plant was known to be widely distributed throughout the province, and the fibre is largely employed by the natives for rope-making. In most cases, however, they do not prepare the fibre thoroughly, but leave it with a slight greenish colour due to the imperfect separation of the cellular leaf tissue.

The sample had a greenish colour; it was of fair strength and the length of staple varied from 3 to 5 feet.

The material was cleaned as far as possible by hackling, and was then submitted to chemical examination. The results obtained are given in the following table, where they are compared with the figures furnished by a sample of the same fibre from Sierra Leone:—

	Sansevieria guineensis fibre from the Bahr-el-Ghazal. Per cent.	*Sansevieria guineensis* fibre from Sierra Leone. Per cent.
Moisture	9·5	10·6
Ash	3·8	0·4
α-Hydrolysis (loss)	14·5	8·9
β-Hydrolysis (loss) ...	24·1	13·9
Acid purification (loss) ...	2·0	1·8
Cellulose	71·5	78·0
Length of ultimate fibre ...	1·1-3·3 mm.	1·5-5 mm.

From these results it is evident that this sample of fibre from the Bahr-el-Ghazal was distinctly inferior to the specimen from Sierra Leone, but it is probable that the greater loss on hydrolysis and the lower percentage of cellulose were largely due to the imperfect preparation of the fibre. This conclusion was confirmed by the large proportion of ash.

There can be little doubt, however, that, if carefully prepared, this Sansevieria fibre from the Bahr-el-Ghazal would be of good quality and would probably find a ready market.

It was suggested that a larger sample of this fibre should be forwarded from the Bahr-el-Ghazal to the Imperial Institute for further examination and commercial valuation, and it was recommended that efforts should be made to obtain a white fibre of long staple.

At a later date another sample of the fibre, prepared in the Bahr-el-Ghazal, was forwarded for examination by the Sudan agent at Cairo. It consisted of 70 lb. of fibre, which varied in colour from pale buff to brownish-green. It had been very badly prepared and cleaned, the fibres being gummy and having much pulpy matter from the leaves adhering to them. The strength was very irregular; some portions were of fair strength, whilst others, especially the brownish portions, were very weak. The length of the staple varied from 2 to 3 feet.

Material of the quality of this sample would have little or no commercial value, but there is no doubt that, if more care were taken in the preparation, Sansevieria fibre could be obtained from

the Bahr-el-Ghazal, equal in quality to that produced elsewhere, and worth £30 per ton or even more (November, 1906). It was recommended that the points mentioned in the earlier report should be carefully borne in mind, and that the natives should be encouraged to prepare the fibre much more carefully if the product is intended for export.

SOMALILAND PROTECTORATE.

Sansevieria Ehrenbergii.

The so-called "aloe" fibre of Somaliland was first brought to notice in a report (Foreign Office, Miscellaneous Series, No. 225, 1892), by Lieutenant-Colonel E. V. Stace, His Majesty's Consul at Aden, in which it was stated that a bale of the fibre, prepared by the natives, had been sent to England and sold at £16 10s. per ton. Botanical specimens were forwarded to the Royal Gardens, Kew, where the plant was identified as *Sansevieria Ehrenbergii*. (Compare *Kew Bulletin*, 1892, pages 129-132.)

In 1905 a consignment was forwarded to the Imperial Institute by the Commissioner, Somaliland Protectorate, who stated that the fibre grows wild in large areas of Somaliland and that from time to time various European firms have made arrangements with the native tribes to collect and prepare the product but that nothing tangible had resulted. It was also stated that the preparation of the fibre had been undertaken recently as a Government relief measure, and that the fibre had been obtained from *Sansevieria Ehrenbergii* by the usual rough native method of preparation.

The fibre was examined in the Scientific and Technical Department and was referred to several commercial experts for valuation. The sale of the consignment was subsequently entrusted to a well-known firm of fibre brokers. A description of the fibre and the results of its examination are given below.

The consignment consisted of about 1,000 lb. of fibre which, on the whole, was fairly well cleaned and prepared. The material was of good strength, from 2 to 3 feet long, fairly lustrous, and varied in colour from cream to a pale greenish-yellow with occasional greyish stains.

The results of the chemical examination are given in the following table, to which are added for convenience of comparison those furnished by a sample of Sisal hemp from Trinidad and a sample of *Sansevieria trifasciata* from India:—

—	*Sansevieria Ehrenbergii* from Somaliland.	Sisal Hemp from Trinidad.	*Sansevieria trifasciata* from India.
	Per cent.	Per cent.	Per cent.
Moisture	11·2	11·6	9·0
Ash	2·0	1·0	0·6
α-Hydrolysis (loss) ...	10·7	11·7	10·0
β-Hydrolysis (loss) ...	14·1	13·5	12·6
Acid purification (loss)	3·5	1·0	2·3
Cellulose	74·0	77·2	74·4

The length of the ultimate fibres of the *Sansevieria Ehrenbergii* fibre was found to vary between 0·7 and 3·8 mm. (or 0·03 and 0·15 inch) with an average of 2·7 mm. (0·11 inch) which is approximately the same as that of the ultimate fibres of Sisal hemp.

These figures show that the fibre was of good quality and very similar in its chemical composition and behaviour to the *Sansevieria trifasciata* fibre from India. The percentage of cellulose was rather lower than that of the Sisal hemp, but the fibre would no doubt be very durable since it suffered only a moderate loss when boiled with dilute alkali (α- and β-hydrolysis). The proportion of mineral constituents (ash) and the loss sustained on acid purification were sufficiently low to indicate that the fibre was fairly free from impurity.

The commercial experts reported that the fibre would be classed in the market with Sisal hemp, and that the material was of good useful quality, but was not sufficiently well cleaned and contained some discoloured fibre and some hard imperfectly-prepared strands or "runners." The fibre was valued at about £32 to £33 per ton in the London market, the best Sisal hemp being worth £38 per ton on the same date. It was considered that if the product were better cleaned and rather whiter it would be worth £34 to £35 per ton.

The consignment was disposed of by public sale and realised £32 per ton. The broker stated that if the quantity had been larger (10 tons or so) it would have realised £1 or £2 per ton more.

The results of the investigation showed that this fibre from Somaliland was of good quality. Fibres of this class are in considerable demand and realise high prices in the London market. It was stated that there was no doubt that if a product of the quality of this consignment could be exported in large quantities it would find a ready sale, and that the Imperial Institute would be interested to receive particulars of any attempts which might be made to exploit this material on a commercial scale and of the quantities which were likely to be produced.

East Africa Protectorate.

Musa species.

Seven samples of banana fibres have been forwarded to the Imperial Institute by the Director of Agriculture and Forestry, Nairobi, at various times for chemical examination and commercial valuation.

Description of Samples.

No. 1.—This sample, labelled "No. 21/05, Nandi banana fibre," consisted of 5½ lb. of fairly lustrous light-brown fibre, which was well cleaned and prepared and of good strength. The greater part of the sample had a length of 3 feet 5 inches to 4 feet 3 inches, but some shorter fibre, about 2 to 3 feet long, was also present. In the letter from the Director of Agriculture and Forestry, it was stated that the product had been prepared by natives, probably from *Musa Livingstoniana*.

No. 2.—This sample, labelled "No. 22/05, Kericho banana fibre," consisted of 1 lb. of fibre, which resembled the preceding sample in appearance, but was rather more lustrous, lighter in colour, somewhat finer, not quite so strong, and varied in length from 4 to 5 feet."

No. 3.—This was probably derived from *M. Livingstoniana*, and consisted of 1½ lb. of fibre, which was of a brown colour, well prepared, lustrous, soft to the touch, of good but somewhat uneven strength, and from 1 foot 9 inches to 3 feet 8 inches long.

A.—This sample, labelled "No. 23/05, Mwatate banana fibre," consisted of 4 lb. of coarse, light-brown, somewhat lustrous fibre, which was fairly well cleaned and prepared, of fair but uneven strength, and from 4 to 6 feet long.

B.—This sample was labelled "No. 24/05 (*a*), Wild banana, claret-coloured variety. Tree past maturity and partly destroyed by fire. Weight of fibre, 1 lb." The fibre was fairly well cleaned and prepared, of fair lustre and strength, was coarser than the two following samples C and D, but less coarse than A. The length of the material varied from 5 to 6 feet. The product was of uneven colour, the greater part being cream-coloured, whilst a small proportion was stained dark brown.

C.—This sample was labelled "No. 24/05 (*b*), Wild banana, green variety. Tree about three-quarters grown. Weight of fibre, 1 lb." The fibre was of an uneven pale cream colour with light-brown stains, was fairly well cleaned and prepared, strong, of good lustre, and 6 to 8 feet long.

D.—This was labelled "No. 24/05 (*c*), Wild banana fibre, claret-coloured variety. Plant about half-grown. Weight of dry fibre, 1 lb." The fibre was fairly well cleaned and prepared, cream-coloured, lustrous, of good strength and 5 to 6 feet long.

Chemical Examination.

The results of the chemical examination of these samples of banana fibres are collected together in the following table, to which are added for convenience of comparison those furnished by samples of the fibres of *Musa Ensete* and *Musa ulugurensis* from German East Africa, which have also been examined in the Scientific and Technical Department, and are described on page 108.

—	Samples from British East Africa.							Samples from German East Africa.		
	No. 1.	No. 2.	No. 3.	Sample A.	Sample B.	Sample C.	Sample D.	*Musa Ensete*, Quality 1.	*Musa Ensete*, Quality 2.	*Musa ulugurensis*.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	10·4	10·8	9·5	10·8	9·9	10·3	10·7	9·7	9·4	10·2
Ash	2·2	3·4	2·9	1·2	4·8	4·8	2·3	1·5	1·7	1·6
α-Hydrolysis (loss)..	20·1	16·5	17·5	10·5	22·4	15·8	15·1	10·3	13·0	22·9
β-Hydrolysis (loss)..	24·0	25·6	25·5	14·2	26·4	20·3	29·2	15·1	18·2	24·7
Acid purification (loss).	5·8	3·[illegible]	6·9	3·0	7·3	5·1	4·7	0·8	3·7	6·5
Cellulose	74·4	73·0	71·8	77·8	71·5	73·4	72·3	78·1	74·5	70·7
Length of ultimate fibre.	1·4-2·5 mm. (0·06-0·10 in.)	1·6-3·1 mm. (0·06-0·12 in.)	1·5-6 mm. (0·06 0·24 in.)	—	—	—	—	2·6-5 mm. (0·10-0·20 in.)	2·6-5 mm. (0·10-0·20 in.)	2·2-4·7 mm. (0·09-0·19 in.)

Samples Nos. 1 and 2.—The results show that these banana fibres, although of good quality, are not equal to that of the *M. Ensete,* this being particularly noticeable in the amount of loss sustained on boiling with dilute alkali (α- and β-hydrolysis). They appear, however, to be somewhat superior to the *M. ulugurensis* fibre, since they contain a larger proportion of cellulose.

Sample No. 3.—It is evident that in chemical composition and behaviour this fibre is inferior to that of *M. Ensete,* but compares favourably with that of *M. ulugurensis.* The sample of *M. ulugurensis,* however, was superior in colour, length, and general appearance, and was therefore more valuable.

Sample A.—On comparing the results given by this fibre with those furnished by the two fibres from German East Africa it is evident that in chemical composition and behaviour this sample compares favourably with *M. Ensete* (quality 1), since it is fairly resistant to the action of boiling dilute alkali, as shown by the comparatively small loss on α- and β-hydrolysis, and contains a high proportion of cellulose. The material was, however, much inferior in colour to the *M. Ensete* fibre.

Sample B.—This sample is evidently somewhat inferior in chemical composition and behaviour to the samples A, C, and D sent at the same time, but resembles the *M. ulugurensis* fibre.

Sample C.—The figures show that this sample resembles B, but is somewhat richer in cellulose.

Sample D.—This sample, like B and C, resembles the *M. ulugurensis* fibre in chemical composition and behaviour.

Commercial Valuation.

Sample No. 1.—The commercial experts reported that this fibre was very strong, of fair length, and of colour similar to that of Manila hemp, but that a part of the sample consisted of short fibre. The product was valued at £31 to £32 per ton in the London market.

Sample No. 2.—This was reported to be very strong, soft, very fine, clean, of fairly good colour and length, and worth from £40 to £42 per ton.

These two valuations were based on the current prices of the best grades of Manila hemp, which varied at that time from £43 to £57 per ton.

Sample No. 3.—The commercial experts, to whom this sample was referred, reported that the fibre was short, soft, of dull yellowish colour and mixed strength, and worth about £20 to £22 per ton.

Sample A.—This was described as rather harsh, of yellowish colour and satisfactory length, and consisting of fibre of two lengths, the shorter being worth £26 and the longer £30 per ton in the London market.

Sample B.—The commercial experts reported that this fibre was of satisfactory length, fair colour and good strength (with the exception of the stained portions, which were weak), and

ecommended that care should be taken that the juice of the lant does not stain the fibre, since thereby both the strength nd commercial value of the product are depreciated. The aterial was valued at £34 to £35 per ton.

Sample C.—This fibre was regarded as of excellent quality, ell prepared, strong, and lustrous, and worth £48 to £50 per on.

Sample D.—The commercial experts reported that this material as of good length, colour, and strength, had been carefully repared, and was worth £45 to £46 per ton.

The results of the examination of these fibres showed that, on e whole, the samples were well prepared and of good quality. n the opinion of the commercial experts, these products were mparable with the best fibres used for rope-making, were milar to the most expensive grades of Manila hemp, and would eet with a ready sale in the London market.

It was pointed out that it is important to remember that in porting such materials the fibre should be roughly sorted cording to length, so that the value of the longer fibre may not e lessened by the presence of the shorter product, as is the case r example in Sample No. 1. Information as to the botanical entity of the plants from which these various samples were rived was asked for.

Agave rigida var. *sisalana.*

A sample of the fibre of *Agave rigida* var. *sisalana*, grown at e Government Farm, Nairobi, and prepared by the Afro-merican Company, Voi, was forwarded by the Director of griculture in 1906. The sample was well cleaned and pre-red, nearly white, fairly lustrous, and of very good strength. he length was irregular, varying from 2 feet to 3 feet 6 inches, ith an average of about 3 feet.

On chemical examination, it gave the following results:—

	Per cent.
Moisture	9·6
Ash	0·8
α-Hydrolysis (loss)	11·3
β-Hydrolysis (loss)	14·8
Acid purification (loss)	2·1
Cellulose	77·4

This fibre compared favourably with other samples of Sisal emp examined at the Imperial Institute, and would find a ready arket. The product was valued by commercial experts at £34 £35 per ton (with Mexican Sisal at £34 10s. per ton).

Furcræa gigantea.

A sample of the fibre of *Furcræa gigantea*, grown at Mazeras d prepared by the Afro-American Company, Voi, was for-arded by the Director of Agriculture in 1906. The product d not been well prepared, and still retained gummy matter

and adherent tissue. The colour was uneven, but mostly dark brown and without lustre. The strength was very poor, and the length was irregular, with an average of about 4 feet 3 inches. The fibre was regarded as worth about £22 to £23 per ton in the London market, but would have been more valuable if it had been better prepared. On the date of this valuation, Mauritius hemp was quoted at £26 to £32 per ton.

Sansevieria species.

Five samples of *Sansevieria* fibres were forwarded to the Imperial Institute for examination by the Director of Agriculture, Nairobi, British East Africa, in 1905.

Sample No. 1. This consisted of slightly lustrous, brownish-coloured fibre which had been badly cleaned. It was harsh to the touch, fairly strong, and varied in length from 2 feet 3 inches to 3 feet 3 inches.

The corresponding botanical specimen was identified at the Royal Gardens, Kew, as *Sansevieria Ehrenbergii*, Schweinf.

On chemical examination the fibre gave the following results:—

	Per cent.
Moisture	9·5
Ash	1·7
α-Hydrolysis (loss)	13·4
β-Hydrolysis (loss)	17·3
Acid purification (loss)	5·7
Cellulose	64·4

Length of ultimate fibre ... 1·3-2·8 mm. (0·05-0·11 inch).

On comparing these results with those yielded by other specimens of *Sansevieria* fibres examined (see table on page 67), it is evident that the present sample of fibre contains a low proportion of cellulose, and was very susceptible to attack by boiling dilute alkali (α- and β-hydrolysis). There can be no doubt that this inferiority was due to the defective preparation of the sample.

The commercial experts to whom the sample was submitted reported that the fibre was harsh, dry, of yellowish colour, fair strength, had been roughly cleaned, and was worth about £28 per ton in the London market.

Sample No. 2. This consisted of *Sansevieria guineensis* fibre, which was of a cream colour with brownish stains, had been very imperfectly cleaned, was harsh, slightly lustrous, of poor strength, and from 3 feet to 3 feet 9 inches long. It was of much coarser character than the sample of *S. guineensis* from Sierra Leone referred to in the table on page 67.

The results of the chemical examination are given below, and show, as in the case of sample No. 1, that the fibre was of comparatively poor quality, due chiefly, if not entirely, to its having been incompletely cleaned.

	Per cent.
Moisture	8·9
Ash	1·2
α-Hydrolysis (loss)	11·5
β-Hydrolysis (loss)	15·3
Acid purification (loss)	3·8
Cellulose	62·0

The commercial experts reported that this fibre was softer than the preceding sample, was of fair length, mixed yellowish colour, partly tender, only half cleaned, and contained some hard ends, and was of nominal value £27 to £28 per ton.

Sample No. 3. This, described as the fibre of *S. Ehrenbergii*, consisted of pale brown fibre, which had been very badly cleaned, the ends of the leaves having been left untouched. The material was harsh, fairly lustrous, somewhat weak and brittle, and varied in length from 4 feet 3 inches to 5 feet 9 inches.

On chemical examination, this fibre gave the following results. The remarks made with reference to the results obtained with samples Nos. 1 and 2 are equally applicable to this sample.

	Per cent.
Moisture	9·4
Ash	1·0
α-Hydrolysis (loss)	16·0
β-Hydrolysis (loss)	21·8
Acid purification (loss)	1·6
Cellulose	59·2

The commercial experts reported that the fibre was "rough and pithy," of good length, only half cleaned, and worth about £26 to £27 per ton.

Sample No. 4. This sample was of a cream colour and had been fairly well cleaned, but contained a small amount of adherent green tissue. The material was fairly lustrous, less harsh than the three previous samples, of fair strength, and about 2 feet long.

The corresponding botanical specimen could not be identified in the absence of flowers.

The results of the chemical examination are given below:—

	Per cent.
Moisture	9·8
Ash	1·0
α-Hydrolysis (loss)	10·8
β-Hydrolysis (loss)	14·1
Cellulose	76·1

On comparing these figures with those obtained with other *Sansevieria* fibres (see table on page 67), it is seen that this fibre was of good quality and, in its chemical composition and behaviour, closely resembled the sample of *Sansevieria zeylanica* received from Assam.

The commercial experts reported that the fibre was short, soft, of mixed strength, and worth £24 to £25 per ton.

Sample No. 5. This consisted of pale brown fibre of a stiff, brush-like character. The material was of good strength, but somewhat brittle, and was about 1 foot 6 inches long.

The corresponding botanical specimen was identified at the Royal Gardens, Kew, as *S. guineensis*, Willd.

On chemical examination the fibre gave the following results:—

	Per cent.
Moisture	9·1
Ash	0·7
α-Hydrolysis (loss)	8·3
β-Hydrolysis (loss)	12·6
Acid purification (loss)	1·2
Cellulose	61·6

On comparing these figures with those yielded by a sample of *S. guineensis* fibre from Sierra Leone (see table below), it is evident that there was a great difference in the proportion of cellulose contained in these materials. A corresponding difference appeared in the general character of the fibres, that from Sierra Leone being much finer and softer and possessing none of the stiff, brush-like nature which marked the present sample. This variation may have been due to a difference in the age of the plants, or of the leaves from which the fibres were extracted, or to some local circumstances affecting the growth of the plant and the character of the fibre produced. This sample of *S. guineensis* fibre appeared to have been better cleaned than sample No. 2, but was much coarser.

The commercial experts reported that the sample consisted of short, stiff fibre, fairly well cleaned, of good strength, and worth from £20 to £22 per ton.

In the following table, the results obtained in the chemical investigation of these fibres are collected and compared with the corresponding figures furnished by some other specimens of *Sansevieria* fibres previously examined in the Scientific and Technical Department.

—	*Sansevieria* fibre No. 1.	*Sansevieria* fibre No. 2.	*Sansevieria* fibre No. 3.	*Sansevieria* fibre No. 4.	*Sansevieria* fibre No. 5.	*Sansevieria guineensis* from Sierra Leone.	*Sansevieria zeylanica* from Angoorie, Assam.	*Sansevieria trifasciata* from Nazira, Assam.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	9·5	8·9	9·4	9·8	9·1	10·6	9·4	9·0
Ash	1·7	1·2	1·0	1·0	0·7	0·4	0·[illegible]	[illegible]·6
α-Hydrolysis (loss)	13·4	11·5	16·0	10·8	8·3	8·9	11·8	10·0
β-Hydrolysis (loss)	17·3	15·3	21·8	14·1	12·6	13·9	14·9	12·6
Acid purification (loss) ..	5·[illegible]	3·8	1·6	—	1·2	1·8	1·4	2·3
Cellulose	64·4	62·0	59·2	76·1	61·6	78·0	75·6	74·4

The results of the investigation of these *Sansevieria* fibres led to the conclusion that these products were of good commercial value and would probably repay cultivation. It was recom-

mended that in preparing these materials for export, more care should be exercised in their extraction and cleaning. The commercial experts stated that none of the samples were in good marketable condition, and consequently the values given must be regarded as nominal, but added that if the products were properly cleaned they would probably realise several pounds per ton above the prices quoted.

Many other samples of *Sansevieria* fibres have been received from British East Africa, of which the most important are three collected in the neighbourhood of Voi and forwarded to the Imperial Institute with corresponding botanical specimens by Mr. A. Grenfell, formerly of the Forestry Department of the Transvaal.

The condition of these fibres showed that they had been incompletely cleaned in the process of extracting them from the leaves. The chemical examination was therefore carried out on specimens which had been further cleaned as far as possible in the Scientific and Technical Department by hackling. Unfortunately, however, the results of the chemical examination of fibres which have been imperfectly prepared are not of great value as evidence of the qualities of the true fibre substance since these are more or less obscured by the impurities present.

Sample No. 6 (*Sansevieria Volkensii*, Gürke?). This fibre was derived from a plant which was regarded at Kew as probably *Sansevieria Volkensii*, Gürke. It was of uneven colour varying from yellow to buff with occasional greenish portions. The fibre was not very well prepared, and contained a small quantity of the pulpy matter of the leaves adhering to it. The diameter was irregular, varying from 0·0025 inch to 0·01 inch. The greater part of the fibre had a length of 2 to 3 feet, but some shorter fibre, about 14 to 18 inches long, was also present.

On chemical examination, the following results were obtained, which are discussed later:—

	Per cent.
Moisture	8·4
Ash	1·6
α-Hydrolysis (loss)	9·8
β-Hydrolysis (loss)	15·2
Acid purification (loss)	2·7
Cellulose	68·0
Length of ultimate fibre ...	0·75-3·1 mm. (0·03-0·12 inch).
Diameter of ultimate fibre..	0·02-0·03 mm. (0·0008-0·0012 inch).

The commercial experts reported that the fibre was worth about £28 per ton, and would probably be readily saleable.

Sample No. 7 (*Sansevieria guineensis* ?). This fibre was derived from the flat *Sansevieria* leaves, which are usually regarded as those of *Sansevieria guineensis*. It was stated at Kew, however, that it is impossible to say whether this identification is correct until better specimens including flowers have been examined.

The fibre was badly cleaned and prepared, and contained some of the leaf pulp. A good deal of fine tangled fibre was present. The better cleaned portions were nearly white and of good strength. The diameter was more regular than that of samples 6 and 8 and varied from 0·0035 to 0·012 inch. The greater part of the fibre was from 2 feet 6 inches to 3 feet 5 inches long, but some of it was only about 1 foot 6 inches in length.

When submitted to chemical examination the fibre yielded the following results:—

	Per cent.
Moisture	8·1
Ash	1·4
α-Hydrolysis (loss)	14·0
β-Hydrolysis (loss)	16·6
Acid purification (loss)	4·2
Cellulose	72·4

Length of ultimate fibre ... 1·5-5·1 mm. (0·06-0·20 inch).

Diameter of ultimate fibre... 0·02-0·035 mm. 0·0006-0·0014 inch).

The commercial experts reported that the fibre was of poor quality and varying length, and was worth about £22 per ton c.i.f. London.

Sample No. 8 (*Sansevieria Ehrenbergii?*). This fibre was derived from a species of *Sansevieria* which bears leaves 8 or 9 feet long, and was provisionally regarded by Mr. Grenfell as *Sansevieria Ehrenbergii*. It was considered at Kew, however, that the plant was probably a new species of *Sansevieria*.

This fibre possessed a peculiarity which has been observed at the Imperial Institute in several other specimens of *Sansevieria Ehrenbergii* (?) from British East Africa, and which seems to be a definite characteristic of the fibre of this particular species. This peculiarity is a very marked variation in the diameter of the strands or filaments of fibre. The fibre from the interior of the leaf is fine, whilst that from the more external portions is very coarse. The diameter of the finer fibre varies roughly from 0·001 inch to 0·0055 inch whilst that of the coarser attains to as much as 0·018 inch.

As the question has been raised as to the possibility of separating the coarser fibre into finer strands by means of a degumming process, it may be said at once that this is practically impossible from the nature of the material. It is, of course, the case that both the course and fine strands alike are composed of a mass of ultimate fibres into which they can be resolved by chemical processes. These ultimate fibres are, however, extremely short (about 0·05 inch to 0·2 inch), and are united to one another by a lignified thickening of their walls. The effect of chemical treatment is to cause the solution of the middle lamellae between the thickened ultimate fibres, and so to cause eventually the disintegration of the whole strand into these extremely short portions. It is, therefore, highly improbable, if not altogether impossible, that any process, either chemical or

mechanical, could be devised which would be capable of resolving the coarser strands into finer strands without at the same time sacrificing the length of the material.

The sample of fibre varied in colour from pale brown to white, and in some parts had a greenish tinge. It was badly prepared, the finer fibre being much tangled, and the whole still retaining a considerable quantity of the pulp or softer tissue of the leaf. The coarser fibre was harsh, whilst the finer fibre was soft and weak. The length of the fibre was about 3 to 4 feet, but some small specimens obtained from single leaves were from 6 feet to 6 feet 6 inches long.

In the process of hackling the product in order to clean it and render it fit for chemical examination, the finer fibre owing to its tangled state was entirely removed, so that the chemical results in the following table represent the behaviour and composition of the coarse fibre only:—

	Per cent.
Moisture	8·8
Ash	1·7
α-Hydrolysis (loss)	8·8
β-Hydrolysis (loss)	15·6
Acid purification (loss)	2·2
Cellulose	65·7

Length of ultimate fibre (from the finer material)	1·5-5·1 mm. (0·06-0·2 inch).
Length of ultimate fibre (from the coarser material)	1·3-3·7 mm. (0·05-0·15 inch).
Diameter of ultimate fibre in each case	0·025-0·04 mm. (0·001-0·0016 inch).

Representative specimens of the darker and the lighter coloured fibre were submitted to the commercial experts. The product was reported to be a well-grown fibre of good length, but badly cleaned. The darker portion was valued at £22 per ton, and the lighter at £24 per ton, and it was stated that if the fibre were thoroughly cleaned, it would realise £4 or £5 per ton in advance of these prices.

For convenience of comparison, the results of the chemical examination of these three fibres are collected in the following table, together with those furnished by certain other similar samples of *Sansevieria* fibres previously examined in the Scientific and Technical Department:—

	No. 6. *S. Volkensii* (?).	No. 7. *S. guineensis* (?).	No. 8. *S. Ehrenbergii* (?).	*S. Ehrenbergii* from Somaliland.	*S. guineensis* from Sierra Leone.	*S. Ehrenbergii* from British East Africa.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8·4	8·1	8·8	11·2	10·6	9·5
Ash	1·6	1·4	1·7	2·0	0·4	1·7
α-Hydrolysis (loss) ..	9·8	14·0	8·8	10·7	8·9	13·4
β-Hydrolysis (loss) ..	15·2	16·6	15·6	14·1	13·9	17·3
Acid purification (loss)	2·7	4·2	2·2	3·5	1·8	5·7
Cellulose	68·0	72·4	65·7	74·0	78·0	64·4

A consideration of these figures leads to the following conclusions:—

Sample No. 6, which in general character resembled the fibre of *Sansevieria Ehrenbergii* from Somaliland, was evidently somewhat inferior to the latter, since it contained less cellulose, and was rather more susceptible to the action of dilute alkali as shown by the result of the hydrolysis. It may be mentioned that a small consignment of this Somaliland fibre which was forwarded to the Imperial Institute, was sold in the London market at £32 per ton in November, 1905 (see page 60).

Sample No. 7 was similar to the fibre of *Sansevieria guineensis* from Sierra Leone, but, as shown by the results of the chemical examination, was of decidedly inferior quality, which was no doubt, largely, if not altogether, due to its defective preparation.

Sample No. 8 was of the same character as samples of *Sansevieria Ehrenbergii* (?) from British East Africa, which had been examined previously, but appeared to be slightly superior to the latter.

There is at present great uncertainty with regard to the botanical identity of the various species of *Sansevieria*, owing to the lack of authentic material (including flowers) on which to base determinations. For the present, therefore, it will be the best plan to distinguish provisionally the three plants yielding the fibres described, as *Sansevieria Volkensii*, *S. guineensis*, and *S. Ehrenbergii*.

There is no doubt that all these fibres are of a character which renders them of great utility for rope manufacture and capable of securing a ready market.

It was pointed out that the following points must be observed if the fibres are to realise good prices: (1) It is essential that the product should be cleaned as thoroughly as possible. After leaving the machine it is desirable that the material should immediately be washed in order to remove the juice of the leaf, which, if allowed to dry on the fibre, is liable to stain and weaken it. (2) After being dried, the product should be brushed by means of one of the machines specially designed for this purpose, so that the fragments of dry pulp adhering to the fibre may be removed. (3) It is advisable that the fibre should be roughly graded, according to length, before export, since the presence of short fibre in a consignment which is mostly of good length (4 feet or more) considerably lessens its value.

Three samples of *Sansevieria* fibre, grown and prepared by the Afro-American Company, Voi, were forwarded from East Africa by the Director of Agriculture in 1906.

No. 1, labelled *Sansevieria Ehrenbergii*, consisted of pale buff-coloured fibre which had been well prepared and resembled the East African *S. Ehrenbergii* fibres, previously examined, in consisting of a mixture of coarse and fine strands. The product was of good strength, and from 3 feet to 5 feet 6 inches long, with an average length of about 4 feet 6 inches. On chemical examination, it yielded the following results:—

	Per cent.
Moisture	11·1
Ash	0·6
α-Hydrolysis (loss)	9·4
β-Hydrolysis (loss)	12·1
Acid purification (loss)...	1·3
Cellulose	71·3

The fibre was regarded by commercial experts as worth £28 to £30 per ton in the London market.

No. 2, labelled "*Sansevieria sulcata*," resembled sample No. 1 in being composed of a mixture of fine and coarse fibre, but was not so well cleaned and was rather finer. The colour varied from buff to light brown, with slight lustre. The fibre was of somewhat poor strength, and from 3 feet 4 inches to 5 feet 4 inches long, with an average length of 4 feet. On chemical examination, it gave the following results:—

	Per cent.
Moisture	10·3
Ash	0·7
α-Hydrolysis (loss)	11·4
β-Hydrolysis (loss)	12·4
Acid purification	1·4
Cellulose	63·5
Length of ultimate fibres...	0·5 mm. to 2·4 mm. (or 0·02 to 0·1 inch). Average, 1·7 mm. (or 0·07 inch).

The product was valued at £28 to £30 per ton.

No. 3, labelled "*Sansevieria* sp.," had been well cleaned, was of buff colour and was finer and of more even diameter than Nos. 1 and 2. The material was lacking in lustre, was of somewhat poor strength and very irregular length, varying from 1 foot 8 inches to 3 feet 7 inches. On chemical examination, the following results were obtained:—

	Per cent.
Moisture	10·4
Ash	0·8
α-Hydrolysis (loss)	8·6
β-Hydrolysis (loss)	12·7
Acid purification	2·6
Cellulose	66·5

The product was regarded as worth £25 to £26 per ton in the London market.

The *Sansevieria* fibres, Nos. 1, 2, and 3, had been insufficiently cleaned, and a considerable quantity of pulpy matter still remained adhering to them. The three samples were very similar in quality. No. 2 contained a rather low percentage of cellulose, and was in this respect inferior to Nos. 1 and 3. No. 3 was the shortest in length of staple, and was, consequently, less valuable than the other two. All three samples were very

uneven in length, and their value was thus diminished. No. 3 somewhat resembled the fibre of *Sansevieria guineensis*, but was decidedly inferior to samples from Sierra Leonne examined at the Imperial Institute (see page 87).

Such fibres would find a ready sale for the manufacture of rope, but would realise better prices if carefully sorted according to length and colour.

In 1907, a sample of "Tuor" fibre was received from the Acting Director of Agriculture in the East Africa Protectorate. It consisted of clean, well-prepared fibre, pale yellow in colour, and of a fair lustre. No information was supplied regarding the botanical origin of the fibre, but a botanical specimen received subsequently was identified at Kew as *Sansevieria guineensis*. The strength of the fibre was very good, and its length of staple 3 feet. On analysis, the following results were obtained:—

	Per cent.
Moisture	8·8
Ash	1·2
α-Hydrolysis (loss)	12·4
β-Hydrolysis (loss)	16·1
Acid purification (loss)	4·5
Cellulose	69·9
Length of ultimate fibre	1-5 mm.
Average	3 mm.

These results show that the "Tuor" fibre was somewhat inferior in composition to a sample of *S. Ehrenbergii* fibre, from Somaliland, examined at the Imperial Institute (see page 60), but was superior in strength, and, on the whole, was of very good quality and readily saleable. Commercial experts valued the sample at £32 to £33 per ton, which was then about the current price of Mexican sisal hemp.

A sample of the fibre of *Sansevieria Stuckyi* from the East Africa Protectorate consisted of fine, light buff-coloured fibre up to 8 feet in length and of even diameter, but very pulpy and badly cleaned. The fibre had no lustre. On chemical examination it gave the following results:—

	Per cent.
Moisture	8·7
Ash	0·7
α-Hydrolysis (loss)	6·9
β Hydrolysis (loss)	9·4
Acid purification (loss)	0·5
Cellulose	67·2
Length of ultimate fibres	1·5 mm. to 3·0 mm.; mean 2·3 mm. (or 0·06 inch to 0·12 inch; mean 0·09 inch).

The percentage of cellulose was low, but as the loss on hydrolysis was small the fibre might be expected to be durable.

This was the first sample of the fibre of *Sansevieria Stuckyi* received at the Imperial Institute, so that no results were available for comparison. In most respects, however, the fibre compared favourably with other Sansevieria fibres. The strength of the sample was somewhat poor, though this may have been due more to imperfect cleaning and preparation than to inherent weakness of the fibre.

With regard to the mechanical strength of the fibre, the following results were obtained from tests made in comparison with Manila hemp:—

		Sansevieria Stuckyi.	Manila Hemp.
Strength	(grams)	483·2	901·4
Elongation	(per cent.)	4·23	2·96

A large number of tests were carried out and the above results were obtained from three series of fibres of corresponding weight and sectional area.

Uganda Protectorate.

Asclepias semilunata.

A sample of fibre, derived from a species of *Asclepias* occurring in Uganda and known locally as "Kafumba" fibre, was forwarded to the Imperial Institute for examination by H.M. Commissioner. The plant yielding the fibre was stated to occur in Bugangadzi. This plant has been identified at Kew as *Asclepias semilunata*, N. E. Br.

The sample of fibre sent for examination weighed only 4 oz., and consisted of five small bundles. The fibre was lustrous and almost white, but was marked by a few patches of a black substance, which had not been removed in the cleaning process. It possessed considerable strength, and the length of staple ranged from 2 to 3 feet.

The chemical examination furnished the following results, the percentages, other than that of moisture, being expressed on the dry material:—

	Per cent.
Moisture	7·7
Ash	3·2
α-Hydrolysis (loss)	12·9
β-Hydrolysis (loss)	19·2
Mercerisation (loss)	6·0
Acid purification (loss)	6·2
Nitration (gain)	46·9
Cellulose	80·4

Length of ultimate fibre 20-27 mm. (0·8-1·08 inches)

The percentage of cellulose is high, and the fibre is evidently of good quality, though the losses on hydrolysis and acid purification are considerable. The marked action of weak alkalis upon the fibre, as shown by the loss occurring on hydrolysis, suggests

that it may not prove very durable in use, whilst the high loss on acid purification indicates that more careful and thorough cleaning is desirable.

The nitrated fibre was nearly white, and no purple colour was produced when the fibre was treated with sodium sulphite after chlorination, both of which facts indicate that the fibre is not lignified, but consists probably of pecto-celluloses. In this respect, and also in the high percentage of cellulose, this *Asclepias* fibre from Uganda resembles the fibres of *Marsdenia* and *Cryptostegia*, and it is noteworthy that these three genera belong to the same natural order, *i.e. Asclepiadaceæ*. (Compare pages 53-55.)

The following statement summarises the results obtained in the examination at the Imperial Institute of the fibres from *Marsdenia tenacissima* and *Cryptostegia grandiflora* for comparison with those furnished by the present sample of *Asclepias* fibre:—

	Fibre of *Asclepias semilunata* from Uganda.	Fibre of *Marsdenia tenacissima* from India.	Fibre of *Cryptostegia grandiflora* from India.
	Per cent.	Per cent.	Per cent.
Moisture	7·7	7·7	7·9
Ash	3·2	1·5	0·95
α-Hydrolysis (loss)	12·9	7·8	5·2
β-Hydrolysis (loss)	19·2	8·9	9·8
Mercerisation (loss)	6·0	4·9	4·3
Acid purification (loss) ...	6·2	3·5	1·2
Gain on nitration	46·9	53·9	49·0
Cellulose	80·4	91·5	92·0
Length of ultimate fibre	20–27 mm. (0·8–1·1 in.)	10–30 mm. (0·4–1·2 in.)	10–50 mm. (0·4–2·4 in.)
Length of staple	2–3 feet.	12–13 in.	16–20 in.

A comparison of these figures show that this sample of *Asclepias* fibre from Uganda was distinctly inferior to the others, the percentage of cellulose being lower, whilst the ash and the losses on hydrolysis and acid purification were considerably greater. It is possible, however, that the fibre could be improved in these respects by careful preparation. In the case of *Asclepias semilunata*, the length of the ultimate fibres is not so great as in the other two fibres, but it appears to be more uniform, and the staple is much longer.

Experiments are being made with fibres of this type to determine their suitability for use in the manufacture of explosives, and, if it is found possible to utilise them in this way, a large demand, at prices from £20 to £25 per ton, may be anticipated. For this purpose the length of staple would be immaterial. If, however, the fibre of *Asclepias semilunata* can be obtained more uniform in length and equal to the longest fibres in the present sample, *i.e.* 3 feet, it is thought by technical experts that it would be suitable for rough textile purposes, and in this case its value

would be from £10 to £15 per ton greater than the above quotation.

The fibre of *Asclepias semilunata* therefore appears worthy of further attention in Uganda, especially if the plant is abundant or can be easily cultivated. In this case efforts should be directed to the production of a uniformly long fibre, as the value of the product in this form will be much greater than if a considerable proportion of short fibres is present. The short fibres would probably only be commercially useful in the event of the technical experiments, to which reference has been made, proving successful.

A larger sample was received at a later date from the Botanical and Scientific Department, Entebbe, and was examined with the following results:—

The fibre varied in colour from white to pale brown, and was of good lustre and excellent strength. On the whole it was well cleaned and prepared, but some portions are rather gummy and dirty. The greater part of the sample was 3-4 feet long, but some was 5 feet, whilst a small quantity was less than 3 feet in length.

On chemical examination it gave constants which are recorded below in comparison with those of the earlier sample:—

	Present sample. Per cent.	Previous sample. Per cent.
Moisture	9·9	7·7
Ash	2·1	3·2
α-Hydrolysis (loss)	10·0	12·9
β-Hydrolysis (loss)	16·5	19·2
Acid purification (loss)	5·3	6·2
Cellulose	88·1	80·4
Nitration (gain)	49·7	46·9

These results show that the fibre was of excellent quality and superior to the sample previously examined. The percentage of cellulose was very high. The somewhat large loss on acid purification indicates the presence of gummy matter, which could no doubt be removed in the course of preparation. The value of the material would also be increased if it could be prepared free from the short fibre which was mixed with it. It could be used in the manufacture of rope and twine. The fibre was regarded by commercial experts as worth from £28 to £33 per ton and readily saleable in large quantities, say, 50 to 100 tons at a time.

Furcræa gigantea.

Two samples of Mauritius hemp were forwarded to the Imperial Institute by the Botanical and Scientific Department, Entebbe, Uganda. One of these had been prepared by hand, and the other by machinery.

The sample which had been prepared by hand consisted of buff-coloured fibre of fair lustre, but had not been very well cleaned, a certain amount of gummy and pulpy matter still adhering to it.

The fibre was about 3 feet long and rather weak, but on the whole of fair quality. The deficiency in strength was probably due to insufficient washing during preparation, the fibre having been weakened by the plant juices which had been allowed to dry in contact with it. The product was valued at £25 to £25 10s. per ton, when Mauritius hemp was quoted in the London market at £25 to £30 per ton.

The sample which had been prepared by machinery was inferior to the preceding sample in colour and lustre. The strength was uneven and the length irregular, a good deal of short fibre being present. The material was regarded as probably worth about £15 to £20 per ton.

NYASALAND PROTECTORATE.

Furcræa gigantea.

Furcræa gigantea, the plant from which Mauritius hemp is derived, is stated to have been introduced into British Central Africa and found to grow well there.

A sample of the fibre was supplied by the Scientific Department at Zomba. It was clean, fairly white in colour, and had a staple about 40 inches in length.

The results of its chemical examination in the Scientific and Technical Department of the Imperial Institute are given in the following table, and are there compared with those obtained with specimens of the fibre of *Furcræa gigantea* received from Southern India, Grenada, and Victoria:—

—	B. C. A. sample.	S. Indian sample.	Grenada sample.	Victoria sample.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	8·7	9·8	10·2	11·6
Ash ...	1·1	—	2·4	2·3
α-Hydrolysis (loss) ...	10·0	12·4	14·9	13·0
β-Hydrolysis (loss) ...	14·5	14·5	22·0	23·5
Acid purification (loss)...	1·7	1·7	3·8	5·6
Mercerisation (loss) ...	8·7	11·4	16·0	16·2
Nitration (gain) ...	38·1	40·7	34·0	34·0
Cellulose ...	75·8	77 7	77·8	72·2
Length of ultimate fibre in mm.	2–5 (average 3·5.)	2–5	1–5	1–3

It is evident from these results that this sample of fibre was of excellent quality. In its chemical behaviour and composition it closely resembled the specimen from Southern India, whilst it was distinctly superior to those from Grenada and Victoria. It was less susceptible to the action of alkali than any of the other samples as shown by the smaller losses sustained on mercerisation and hydrolysis, and it was therefore in a more useful and durable condition.

Representative specimens of this fibre were submitted to brokers for commercial valuation. They reported that the fibre was clean, of fair strength and colour, but rather short, and was worth from £26 to £30 per ton.

Sansevieria cylindrica.

This plant is said to occur in all parts of the Shiré Highlands, but most abundantly at Mlanje, where it grows vigorously.

A sample of the fibre was supplied by Mr. H. Brown, of Mlanje. It was of a pale yellowish colour and fairly clean. Its staple had an average length of 5 feet 3 inches.

In the following table the results of its chemical examination are compared with those of the fibres of other species of *Sansevieria*, which have also been examined in the Department:—

—	*Sansevieria cylindrica* from B. C. A.	*Sansevieria zeylanica* from Assam.	*Sansevieria zeylanica* from Grenada.	*Sansevieria guineensis* from Sierra Leone.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	11·4	9·4	9·5	10·6
Ash	1·6	0·7	1·4	0·4
α-Hydrolysis (loss)	18·8	11·8	11·9	8·9
β-Hydrolysis (loss)	27·7	14·9	17·2	13·9
Acid purification (loss)... ...	2·75	1·4	0·8	1·8
Mercerisation (loss)	7·9	11·6	14·5	8·6
Nitration (gain)...	35·7	33·5	28·6	29·6
Cellulose	79·1	75·6	72·7	78·0
Length of ultimate fibre in mm.	3–6·5 (average 4·7.)	1·6–3·5	1-5	1·5–5

These figures show that in certain points, viz., percentage of cellulose and length of ultimate fibre, this sample of the fibre of *Sansevieria cylindrica* was superior to those of the other species examined. It was, however, more readily attacked by alkaline hydrolysis and was, therefore, likely to be less durable.

The brokers reported that the sample had not been well prepared and was of uneven strength, but that, if properly prepared, its average market value would be about £25 per ton. It was recommended that a second sample of this fibre, more carefully prepared, should be sent to the Imperial Institute for examination and valuation.

RHODESIA.

Musa species.

A specimen of banana fibre, grown in Southern Rhodesia, was forwarded to the Imperial Institute by the British South Africa Company in 1903.

The product was of a dull, pale brown colour, and had a staple of average length, 27 inches. The brokers reported that it was a somewhat soft fibre, of fair strength, stronger and more even than is usually the case with banana fibre, and worth from £25 to £26 per ton. This sample was much superior to specimens of the fibre received from Sierra Leone, which were examined in the Scientific and Technical Department of the Imperial Institute and reported on in the *Bulletin of the Imperial Institute*, 1903, Vol. I., page 21.

Two small specimens of similar fibre were received at the Imperial Institute in 1907. The larger sample, described as having been dried with coarse "mealie" meal, was a fine buff-coloured fibre, fairly well cleaned but lacking in lustre. It was of very fair strength but rather short for rope-making, the length of staple being only up to 2½ feet.

The smaller sample, described as having been dried in the sun, was uneven in colour and somewhat darker than the other. It was of rather poor strength, and had a length of staple up to 1½ feet.

The fibre was evidently derived from a species of *Musa* (the bananas and plantains). If it could be obtained of better length and lustre, it would find a ready market, competing with "fair" or "good" Manila hemps, quoted in the London market at £37 to £40 and £40 to £44 per ton, respectively (July, 1907). For rope-making the length of staple should be not less than 3 to 4 feet.

Agave species.

A sample of fibre, forwarded to the Imperial Institute in 1903 by the British South Africa Company, was stated to have been derived from a species of *Agave*. It consisted of soft, fine fibre, of good colour, well cleaned, and fairly strong. Its average length of staple was 33 inches. The brokers reported that its character resembled that of Mauritius hemp rather than that of Sisal, and that it would be worth from £32 to £34 per ton.

"*Lokosi*" *Fibre.*

This sample of fibre from North-Western Rhodesia was forwarded for examination to the Imperial Institute by the British South Africa Company. It was sent to the United Kingdom by the District Commissioner at Livingstone, Victoria Falls, who furnished the following information regarding it. The plant from which the fibre is obtained is known locally as "Lokosi," but as no herbarium specimens were forwarded it is impossible to express a definite opinion regarding its botanical identity. A rough sketch of the plant was furnished, from which it seems probable that the latter may be a species of *Agave* or *Sansevieria*, and this view is confirmed by the character of the fibre. The plant is stated to be invariably found on the Mopani veldt, and to grow in considerable abundance along the Zambesi Valley. The natives consider the fibre to be the strongest obtainable in the country.

The sample consisted of well-cleaned, cream-coloured fibre It possessed fair strength, and the length of staple was 2 feet 6 inches.

The chemical examination of the fibre gave the following results. For comparison the figures furnished by a sample of Sisal hemp from the Bahamas are given:—

	Fibre from North-Western Rhodesia. Per cent.	Sisal hemp from the Bahamas. Per cent.
Moisture	9·2	12·8
Ash	1·3	4·4
α-Hydrolysis (loss) ..	15·4	12·0
β-Hydrolysis (loss) ...	21·4	16·1
Mercerisation (loss) ...	12·4	13·4
Acid purification (loss) ...	6·0	8·1
Nitration (gain)	18·0	29·7
Cellulose	70·3	75·9
Length of ultimate fibre...	0·8-3·0 mm. (0·03-0·12 inch)	—

A comparison of these figures shows that the "Lokosi" fibre was inferior to the sample of Sisal hemp from the Bahamas, chiefly on account of the lower percentage of cellulose and the greater loss which occurred on hydrolysis. Its susceptibility to the action of weak alkalis (as shown by the loss suffered on hydrolysis) suggested that it might not prove so durable in use as Sisal hemp, but the material might be improved in this respect by more careful preparation.

The fibre would be suitable for rope-making, but its rather short staple would reduce its market value for this purpose. Samples were submitted for valuation to commercial experts, who reported that a consignment of similar character would probably realise from £28 to £30 per ton in London, whereas if the fibre could be obtained 3 feet or more in length, the price might be increased by £5 per ton.

It seems probable that this fibre could be utilised commercially, and in view of the abundant distribution of the plant in certain districts it was suggested that it would be worth while to prepare a trial consignment for sale in the London market.

Furcræa gigantea.

A sample of fibre from Southern Rhodesia was forwarded for examination to the Imperial Institute by the British South Africa Company in 1906, and was accompanied by a sketch and description of the plant from which the fibre was obtained. From the particulars supplied it seemed very probable that the plant was *Furcræa gigantea.*

The sample consisted of nearly white lustrous fibre, which was well cleaned and prepared. It was from 6 feet to 6 feet 6 inches in length, and possessed fair but rather uneven strength. The

following table gives the results of the chemical examination of the fibre:—

	Per cent.
Moisture	9·7
Ash	0·7
α-Hydrolysis (loss)	10·4
β-Hydrolysis (loss)	13·9
Acid purification (loss).	0·9
Cellulose	77·0
Length of ultimate fibres ...	0·6 mm. to 6·4 mm. or 0·02 in. to 0·25 in.; mean 4·0 mm. or 0·16 in.

The results indicate that the fibre was of good quality. It was a little superior to previous samples of the fibre of *Furcræa gigantea* examined at the Imperial Institute, the percentage of cellulose being approximately the same, but the loss on hydrolysis lower. The latter fact suggested that the fibre would be rather more durable than average samples of Mauritius hemp.

The sample was submitted for commercial valuation to experts, who described it as clean fibre of good colour and length, and of fair strength. Its value in London was stated to be £26 to £28 per ton (October, 1906).

Sansevieria species (?)

A sample of fibre from Rhodesia forwarded by the Director of Agriculture, Transvaal, consisted of pale buff-coloured fibre, well cleaned and prepared and slightly lustrous. It resembled the fibre of a species of *Sansevieria*. The product was of fair strength and about 2 feet long. Commercial experts reported that if the fibre had been of longer staple (say 4 feet) it would probably have been worth £30 to £35 per ton (June, 1907).

It was recommended that a larger quantity of well-cleaned fibre of long staple should be forwarded for further examination, and that steps should be taken to determine the botanical identity of the plant from which it is obtained.

A sample of fibre, probably derived from *Sansevieria guineensis*, was forwarded for examination by the Land Settlement Department, Salisbury, Rhodesia. It consisted of soft, lustrous, fine, nearly white fibre. It had been fairly well cleaned, except at one end where the bases of the leaves had been left, and was of good strength and about 2 feet long.

If well cleaned and not less than 3 feet in length this fibre would probably be worth about £35 to £40 per ton in London (November, 1907).

A sample of leaves forwarded from Rhodesia were identified at Kew as those of a species of *Sansevieria*, nearly related to the *Sansevieria Andradæ*, God-Leb.

These leaves contained a white, fairly fine fibre which was of good strength and would be of considerable value for the manu-

facture of rope and twine. If the fibre could be obtained in good condition and of a length of not less than 3 feet 6 inches it would probably be worth £28 to £30 per ton in the London market, but if shorter would realise a somewhat lower price.

It was suggested that a few pounds of the fibre prepared from the fresh leaves should be forwarded, so that a report could be furnished on its quality and commercial value. It was recommended that experiments should be made with the object of ascertaining the percentage of fibre yielded by the fresh leaves, and it was pointed out that if the plant did not grow very abundantly in any one locality, experiments would also be necessary to determine whether it could be readily cultivated.

"Nkungadzi" Fibre.

A sample of "Nkungadzi" fibre, forwarded from Southern Rhodesia, was too small for chemical examination or commercial valuation, but the following particulars were furnished regarding it.

The fibre was non-lignified and resembled in this respect the fibres derived from certain plants of the natural order *Asclepiadaceæ*. It was very strong, and if it could be obtained 4 feet or so in length should be useful for rope-making. In these circumstances the fibre, if carefully prepared and well cleaned, might realise about £30 per ton.

It was suggested that the fibre might find a use in the manufacture of explosives, if the percentage of cellulose was sufficiently high, and it was added that for this purpose the length is of no importance, but the fibre must be quite clean and free from bark.

Information was asked for with regard to the botanical name of the plant and the possibility of commercial supplies of the fibre being forthcoming.

TRANSVAAL.

Sansevieria æthiopica.

Samples of leaves and a small specimen of the extracted fibre were forwarded for examination. Some of the whole leaves were submitted to the Royal Gardens, Kew, where they were identified as those of *Sansevieria æthiopica*, Thunb. The leaves were dark green, fleshy and fibrous, and from 7 to 18 inches long. A specimen of the fibre was extracted from the leaves by boiling them with water, and afterwards scraping and washing the product. The fibre thus obtained was fairly strong and fine. The small specimen of extracted fibre accompanying the leaves was much tangled, but was clean, nearly white, fairly strong, and somewhat finer than most samples of *Sansevieria* fibres.

There is no doubt that this fibre is of good quality, and would be of value for the manufacture of cordage. It is desirable, however, that the fibre should be extracted from the larger leaves in order that it may be obtained of greater length. The commercial value of *Sansevieria* fibre depends to a considerable extent on the length of the material.

In order that the economic value of this product might be more definitely determined it was suggested that a sample of the fibre (about 7 pounds) of full length should be carefully prepared and forwarded to the Imperial Institute so that it could be thoroughly examined and its commercial value ascertained by reference to experts.

NATAL.

Furcraea gigantea.

A sample labelled "Aloe fibre—Natal," was forwarded for examination, and consisted of rather lustrous white fibre, which had been fairly well cleaned and prepared. It was of rather uneven strength. The length of staple was 4 feet.

Chemical examination of the fibre gave the following results:—

	Per cent.
Moisture	9·3
Ash	0·9
α-Hydrolysis (loss)	12·7
β-Hydrolysis (loss)...	14·7
Acid purification (loss)	1·7
Cellulose	75·5

The sample was submitted for commercial valuation to experts who described it as corresponding fairly well with "good fair quality" Mauritius hemp, and valued it at £26 10s. to £27 10s. per ton. At the time of this valuation Mauritius hemp was quoted in the London market at £25 to £30 per ton.

CAPE OF GOOD HOPE.

Agave americana.

A sample of *Agave americana* fibre, forwarded from the Cape of Good Hope in 1907, had a yellowish-green colour and slight lustre, but had not been carefully prepared. The strength was fair and the length of the staple about 3 feet. The sample was insufficient for chemical examination. If well prepared and slightly longer (3½ to 4 feet) the fibre would be worth about £30 per ton in the London market and readily saleable. It was pointed out that the fibre should be as nearly white as possible.

WEST AFRICA.

Musa species.

Three specimens of plaintain or banana fibres derived from *Musa paradisiaca* or *M. sapientum* were forwarded from Sierra Leone in 1902 and are described in the *Bulletin of the Imperial Institute*, 1903, **1**, 22. The products were of inferior quality, and although this was largely due to defective preparation it was still considered unlikely that these fibres would be of value for any but local uses.

Southern Nigeria.—Two small samples of fibre from Southern Nigeria were received at the Imperial Institute in June, 1906.

No information regarding the botanical source of the fibres was available, but their native names were given as "Nkupup" and "Ndche Ukom." It was stated that fair quantities of each would be obtainable if a sufficient price could be offered to the natives. The samples, which were labelled 1 and 2, both resembled banana fibre in appearance.

Sample No. 1, "Nkupup." This consisted of buff-coloured, coarse fibre which had been badly cleaned and prepared; many of the fibres were still adhering together in groups in consequence of the gummy matter not having been removed. The strength was poor, and the length of staple varied from 1 foot 9 inches to 3 feet 4 inches.

In the condition of this sample, the fibre would probably be useless for rope-making, and would not realise more than about £10 per ton.

The fibre was stated by experts to resemble banana fibre prepared from a tree bearing fruit, and it was suggested that a better fibre would be obtained if it were prepared in the earlier stages of growth.

Sample No. 2, "Ndche Ukom." This consisted of nearly white, very lustrous fibre. Like No. 1, however, it had not been properly prepared, and the fibres were attached together in groups. It was of fair, but uneven, strength, and the length of staple was about 2 feet.

If well prepared this fibre would be quite suitable for rope-making, but for this purpose the length of the staple should be at least 3 to 4 feet. In the state of this sample, it was regarded as worth about £25 per ton, but would be of greater value if the staple were longer.

Gold Coast.—A specimen of well-cleaned plantain fibre (*Musa sapientum*), which was brownish-white and of good lustre, was forwarded for examination from the Gold Coast in 1907. The strands of fibre were uneven in diameter, this being a usual characteristic of fibres of *Musa* sp. The product was of fair but very irregular strength and about 4 feet long.

The results obtained on chemical examination were as follows:—

	Per cent.
Moisture	10·5
Ash	0·9
α-Hydrolysis (loss)	12·1
β-Hydrolysis (loss)	19·7
Acid purification (loss)	1·6
Cellulose	77·0

This sample of fibre was superior, so far as chemical composition and behaviour are concerned, to other specimens of *Musa sapientum* fibre previously examined at the Imperial Institute. It was very similar to the second quality of *Musa Ensete* fibre from German East Africa (this *Bulletin*, 1905, **3**, 226), and was regarded by commercial experts as worth £40 per ton (with good Manila hemp at £38 to £42 per ton).

A sample of banana fibre (*Musa sapientum*) which was forwarded at the same time consisted of well-cleaned brownish-white fibre, of good lustre, but uneven diameter and very irregular strength. The product was about 4 feet long.

On chemical examination it furnished the following results:—

	Per cent.
Moisture	10·1
Ash	0·8
α-Hydrolysis (loss)	13·0
β-Hydrolysis (loss)	20·7
Acid purification (loss)	1·3
Cellulose	74·0

This fibre was very similar to the preceding sample, and the same remarks are applicable to it. It was valued at £36 per ton (with fair Manila hemp at £35 to £36 per ton).

Agave species.

In 1890 specimens of the leaves of an *Agave* were received in this country from Sherbro in Sierra Leone, where the plant is known as "Wild Sarsaparilla." These leaves were identified at Kew as those of a form of *Agave rigida* (*Kew Bulletin*, 1892, 36). It is evident, therefore, that at some time or other the Sisal hemp plant has been introduced into West Africa, and it is probable that it would be well adapted to cultivation there since it is capable of growth in dry, arid regions, unsuited to most other plants.

Sierra Leone.—A small sample of Sisal hemp from Sierra Leone examined at the Imperial Institute in the early part of 1907 consisted of fairly lustrous fibre which was well cleaned and prepared, and was of fair strength but only 22-27 inches long. The strands or filaments of fibre were finer at one end than the other; the coarser ends were nearly white whilst the finer ends were pale brown.

On chemical examination, this sample yielded the results given in the following table, to which are added for comparison those furnished by samples of Sisal hemp from Trinidad and from the Bahamas which have been examined in the Scientific and Technical Department:—

	Sample from Sierra Leone. Per cent.	Sisal Hemp from Trinidad. Per cent.	Sisal Hemp from the Bahamas. Per cent.
Moisture	9·0	11·6	12·8
Ash	0·8	1·0	4·4
α-Hydrolysis (loss) ...	9·2	11·7	12·0
β-Hydrolysis (loss) ...	14·5	13·5	16·1
Acid purification (loss) ..	0·8	1·0	—
Cellulose	75·4	77·2	75·9
Length of ultimate fibre	0·9-3·0 mm. or 0·04-0·12 inch.		

These figures show that the sample is of good quality and in chemical behaviour compares satisfactorily with the specimens from Trinidad and the Bahamas.

The commercial experts reported that the product was a useful fibre. It was very short but of fair colour and good strength. The material was said to be too short for machine spinning and would perhaps be worth £28 to £30 per ton, although if it were of the usual length of Sisal hemp (about 4 feet) its value would be £33 per ton and upwards (March, 1906).

Furcræa species.

Sierra Leone.—A sample of the fibre of *Furcræa cubensis* from Sierra Leone was examined at the Imperial Institute in 1902 and is described in the *Bulletin of the Imperial Institute* 1903, **1**, 22).

A further specimen received in 1905 consisted of rather badly-cleaned pale brown fibre of poor strength and from 3 to 4 feet long. It was stated that the plant from which this fibre was derived is not indigenous to Sierra Leone but was probably introduced from Kew.

The results of the chemical examination of this specimen are given in the following table and are compared with those furnished by the earlier sample referred to above.

	Present Sample. Per cent.	Sample received in 1902. Per cent.
Moisture	9·1	9·8
Ash	1·0	0·8
α-Hydrolysis (loss)	11·1	13·5
β-Hydrolysis (loss) ...	16·0	19·1
Acid purification (loss) ...	2·6	4·1
Cellulose	79·1	75·3
Length of ultimate fibre	1·7-2·8 mm. or 0·07-0·11 inch.	1·5-5·0 mm. or 0·06-0·20 inch.
Length of staple	3-4 feet.	28-29 inches.

These figures show that in chemical composition and behaviour the present sample is superior to that previously examined, since it is richer in cellulose and suffers smaller loss on hydrolysis and acid purification. The sample is not so well prepared, however, as the earlier sample and is decidedly weaker.

The commercial experts reported that the fibre was of fair length and colour but was of poor quality, tender, inferior to the fibre of *Furcræa gigantea* (Mauritius hemp), and probably worth £24 to £25 per ton.

Sansevieria species.

Sansevieria guineensis is found growing in Sierra Leone in a narrow belt along the sea-shore under the shade of trees. It

also seems to flourish in places remote from the sea and has been planted recently at Lumley and Mabang. In order to create a profitable industry in the fibre of this species, it would be necessary to employ machinery for its extraction; but at present the plants are not sufficiently abundant in any one locality to warrant the introduction of such machines. Although the Governor of Sierra Leone has afforded facilities for the establishment of somewhat extensive Sansevieria plantations, these do not seem to have been taken advantage of yet to any great extent. It has been suggested that the plant should be grown in the belts, cleared from forest, which the Government has proposed to establish for the protection of cultivated land from forest fires.

Sierra Leone.—A sample of the fibre of *Sansevieria guineensis* from Sierra Leone was examined at the Imperial Institute in 1902 and is described in the *Bulletin* (1903, **1**, 22).

Another sample of this fibre which was forwarded from Sierra Leone in 1905 consisted of nearly white, fairly lustrous fibre, which had been well cleaned and prepared. The fibre was fine, strong, and from 3 feet 3 inches to 4 feet 6 inches long.

The results of the chemical examination of this specimen are given in the following table, which also contains those furnished by a sample of *Sansevieria trifasciata* from Assam and by the sample of *Sansevieria guineensis* received from Sierra Leone in 1902.

—	*Sansevieria fibre* from Sierra Leone. Present sample.	*Sansevieria trifasciata* from Assam.	*Sansevieria guineensis* from Sierra Leone. Sample received in 1902.
	Per cent.	Per cent.	Per cent.
Moisture	10·1	9·0	10·6
Ash	0·6	0·6	0·4
α-Hydrolysis (loss)	10·1	10·0	8·9
β-Hydrolysis (loss)	14·1	12·6	13·9
Acid purification (loss) ...	1·7	2·3	1·8
Cellulose	76·2	74·4	78·0
Length of ultimate fibre	2·1–3·1 mm. or 0·08–0·12 in.	—	1·5–5·0 mm. or 0·06–0·20 in.
Length of staple ...	3 ft. 3 in. to 4 ft. 6 in.	4 ft. 6 in.	3 ft.–3 ft. 4 in.

These results indicate that this sample is of good quality, and very similar in chemical composition and behaviour to the samples with which it is compared.

The commercial experts reported that the material was of fair colour and of good length and strength. The opinion was expressed that the fibre would be very useful and that if exported in fair quantity it would sell freely at £33 per ton and upwards (March, 1906).

In 1906 two samples of the fibre of *Sansevieria guineensis* were forwarded by the Governor of Sierra Leone, one of which had been

retted, whilst the other had been prepared without retting. The latter consisted of fine, white, lustrous, well-cleaned fibre of fair strength. The length varied from 1 foot 10 inches to 3 feet 9 inches, most of the fibre being 3 feet long.

The retted sample had an average length of 3 feet, but some of it was 5 feet long. The fibre was fine but not so lustrous or white as the unretted sample, nor was it so well cleaned and prepared, as there were traces of pulpy tissue and some stains on the fibre. The product was very inferior in strength.

The results of the chemical examination of these fibres are given in the table below.

Of these two samples the unretted was the better, for although the retted sample was richer in cellulose and less affected on hydrolysis, it was of inferior colour and poor strength. The unretted sample was also better cleaned and stronger than the previous specimens of Sansevieria fibre received from Sierra Leone.

Commercial experts to whom the fibres were submitted expressed the following opinions. The sample prepared without retting was a fine soft fibre of good colour but rather short in staple. Owing to its shortness the fibre would be unsuitable for rope-making, the required length for this purpose being about 4 feet. Special uses would have to be found for fibre of this character and a nominal value of £40 per ton was quoted for the sample. If of longer staple, it would probably fetch a higher price.

The retted sample was regarded as a rather weak fibre of fair dull colour and medium length, and was valued at £28 to £30 per ton.

	Sansevieria (unretted). Per cent.	*Sansevieria* (retted). Per cent.
Moisture	9·7	9·6
Ash	0·7	0·4
α-Hydrolysis (loss)	10·8	9·7
β-Hydrolysis (loss)	13·3	12·5
Acid purification (loss)	0·8	1·2
Cellulose	78·1	79·5

Length of ultimate fibre ... 0·8-4·3 mm. or 0·03-0·17 in.

A sample of *Sansevieria* fibre, forwarded from Sierra Leone in 1907, consisted of fine, nearly white, fairly lustrous fibre; it had been well cleaned and prepared. The product was of good strength and 3 to 4 feet long. On chemical examination it furnished the following results:—

	Per cent.
Moisture	10·0
Ash	0·8
α-Hydrolysis (loss)	10·8
β-Hydrolysis (loss)	12·4
Acid purification (loss)	2·1
Cellulose	76·5

The material was regarded by commercial experts as worth about £31 per ton (September, 1907).

The fibre was of excellent quality and compared very favourably with samples of *Sansevieria* fibre (*Sansevieria guineensis*) previously received from West Africa.

Southern Nigeria.—Two small samples of the fibre of *Sansevieria guineensis* ("Ojakoko") were sent to the Imperial Institute by the Colonial Secretary of Lagos in 1906. These specimens consisted of badly-prepared fibre of very uneven length. It was evident, however, that by careful preparation a fibre could be obtained of useful quality which would probably be saleable at from £20 to £25 per ton.

It was recommended that greater care should be taken in preparing and cleaning the fibre, and that efforts should be made to obtain a white fibre of long, uniform staple, as in this condition it would realise the highest price.

Gold Coast.—A sample of the fibre of *Sansevieria* sp. (probably *S. guineensis*), forwarded from the Gold Coast, consisted of soft, clean, white, well-prepared fibre, which was fine, of good lustre, of fairly even diameter, and of good strength. The product was about 3 feet 9 inches long. On chemical examination it yielded the following results:—

	Per cent.
Moisture	10·3
Ash	0·2
α-Hydrolysis (loss)	8·8
β-Hydrolysis (loss)	10·5
Acid purification (loss)	1·4
Cellulose	81·8

The samples compared very favourably with other specimens of *Sansevieria guineensis* fibre examined at the Imperial Institute, the loss on hydrolysis being less and the percentage of cellulose higher. The fibre was of excellent quality and suitable for use with the finest Manila hemp: consignments of similar quality would be readily saleable at about £60 per ton.

Dracæna species.

Samples of fibre prepared from the leaves of certain species of *Dracæna* have been received from Sierra Leone and the Gold Coast Colony.

Sierra Leone.—The specimen from Sierra Leone consisted of nearly white, somewhat lustrous fibre, which had been well prepared but was of very poor strength. The product was fairly fine and from 13 to 16 inches long. It was stated that the plant yielding this fibre occurs in the Protectorate or Hinterland of Freetown as well as in the villages, where it is extensively grown for hedges.

The results of the chemical examination of this fibre are given in the following table, and are compared with those furnished by a specimen of the fibre of *Dracæna Draco* from Victoria.

	Sample No. 1 from Sierra Leone. Per cent.	Fibre of *Dracæna Draco* from Victoria. Per cent.
Moisture	10·5	11·2
Ash	0·8	1·7
α-Hydrolysis (loss)	13·8	18·6
β-Hydrolysis (loss)	*18·5*	*22·1*
Acid purification (loss) ...	1·5	—
Cellulose	75·2	69·2
Length of ultimate fibre	1·4-3·6 mm. or 0·06-0·14 in.	1·5-2·5 mm. or 0·06-0·10 in.
Length of staple	13-16 in.	18-22 in.

These figures show that this sample of fibre was decidedly iperior to that of the *Dracæna Draco* in being richer in cellulose nd in sustaining a smaller loss in weight when boiled with dilute iustic alkali (*α*- and *β*-hydrolysis), and for these reasons it would robably prove more durable. The Sierra Leone fibre was also f better colour than the other specimen, but was somewhat in-erior in strength and length of staple.

The commercial experts reported that the fibre was too short or machine spinning, and would probably be classed with long ow. The material was stated to be of fair colour, poor quality, ather weak, and of doubtful value, possibly about £12 to £13 er ton (February, 1906).

Gold Coast.—The sample of *Dracæna* fibre from the Gold Coast olony was stated to have been prepared in the Botanic Gardens, buri, and consisted of clean, well-prepared fibre which was early white, fairly lustrous, of moderate strength and from 12 to 5 inches long.

On chemical examination it gave the following results, for comarison with which the figures furnished by the sample of *racæna Draco* fibre from Victoria are added :—

	Fibre of *Dracæna* sp. from the Gold Coast. Per cent.	Fibre of *Dracæna Draco* from Victoria. Per cent.
Moisture	8·4	11·2
Ash	0·5	1·7
α-Hydrolysis (loss)	16·2	18·6
β-Hydrolysis (loss)	18·5	22·1
Acid purification (loss) ...	1·7	—
Cellulose	66·5	69·2
Length of ultimate fibre	from 0·4 mm. to 2·6 mm. or 0·016 inch to 0·104 inch (mean 1·4 mm. or 0·056 inch)	1·5 mm. to 2·5 mm. or 0·06 to 0·10 inch

It will be seen from these figures that this sample of *Dracæna* fibre from the Gold Coast compared very favourably with that of *Dracæna Draco* from Victoria, except that the percentage of cellulose was a little lower.

The small loss sustained by the present specimen on acid purification indicated that it had been well prepared, but on the other hand, the fibre itself was only of fair quality, as the percentage of cellulose was low and the loss on hydrolysis rather high. The latter fact threw doubt upon the ability of the fibre to resist the action of water, and, moreover, the staple was too short to render the material of much value for rope-making.

The fibre was submitted for valuation to experts, who reported that the price of a new fibre of such short staple is uncertain, but that material represented by the present sample would probably be worth from £12 to £15 per ton in London. If, however, the fibre could be obtained as stiff as the short Aloe fibre from West India it might be worth from £18 to £20 per ton (May, 1906).

On the whole, it would seem scarcely worth while to cultivate this species of *Dracæna* for the sake of its fibre, especially as there are other fibre-yielding plants in the Gold Coast, such as *Sansevieria* and *Hibiscus*, which would probably repay attention much better.

Hibiscus lunariifolius.

Northern Nigeria.—A sample of "Ramma" fibre (*Hibiscus lunariifolius*) from Northern Nigeria, which was regarded as suitable for cordage manufacture is described on page 38.

ST. HELENA.

Furcræa gigantea.

A sample of "St. Helena Aloe" fibre (*Furcræa gigantea*), forwarded to the Imperial Institute in 1906, consisted of nearly white fibre of good lustre, fairly well cleaned and prepared, but containing some pithy matter. The strength was fair on the whole, but somewhat uneven, and the length was about 6 feet. The sample was too small for accurate valuation, but the product was about equal to Mauritius hemp of average quality, and worth about £25 to £27 per ton. The sample was of unusually long staple for Mauritius hemp, which does not as a rule exceed 4 or 5 feet. It was pointed out that the fibre would be of greater value if better cleaned.

Phormium tenax.

A sample of New Zealand hemp (*Phormium tenax*) labelled "St. Helena Flax," was forwarded for examination from St. Helena in 1906. The fibre was lustrous, nearly white to pale buff in colour, but not very well cleaned, there being some green tissue adhering to the fibre. It was of good strength, and 3 feet 6 inches to 4 feet 6 inches long.

The sample was too small for accurate valuation, but was approximately equal to fair quality New Zealand hemp, and

worth about £32 to £33 per ton. It was pointed out that the fibre had not been sufficiently cleaned.

INDIA.

Agave sp. and *Furcræa* sp.

Agave species.—A sample of *Agave* fibre, received from India in 1903, was stated to have been obtained from Cachar, Assam.

The fibre was coarse, but clean, and of good appearance, yellowish-white in colour, and possessed a fine gloss; it was moderately strong, and the average length of staple was 3 feet 8 inches. The results of the chemical examination are given below:—

	Per cent.
Moisture	9·7
Ash	1·5
α-Hydrolysis (loss)	9·8
β-Hydrolysis (loss)	15·7
Mercerising (loss)	7·1
Acid purification (loss)	2·4
Nitration (gain)	34·0
Cellulose	79·6
Length of ultimate fibre	2-4 mm.

These results indicate that the specimen was of good quality, contained a high percentage of true cellulose and would probably be very durable.

Representative samples of the fibre were submitted to two leading firms of fibre brokers for commercial valuation. The fibre was reported to be of good quality, but rather too dry and brittle; its strength, colour, and length were all described as fairly satisfactory. The defects were probably due to faulty methods of preparation. Portions of the sample were of very good quality, being equal to ordinary Sisal hemp from the West Indies and would have realised about the same price, which ranged at that time from £35 to £38 per ton. It is to be remembered, however, that this price was much higher than the average, which may be taken at about £20 to £25 per ton. A trial shipment of one or two tons was recommended, so that spinning and other trials could be made. It was stated that if such trials should prove satisfactory, large quantities could be sold at current prices, fluctuating with the price of Manila hemp.

It was evident from these reports that, properly prepared, the fibre of this species of *Agave* would compare favourably in commerce with ordinary Sisal hemp and would probably command good prices on the London market.

Two samples of *Agave* fibres were forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, with a request that they might be

submitted to chemical examination and that their commercial values might be ascertained. It was stated that the botanical identity of the species from which the first sample was derived had not yet been completely established.

Agave species. — The specimen was labelled "*Agave* species, from the Royal Botanic Gardens, Sibpur." The product was of excellent colour, had been fairly well prepared but imperfectly cleaned, was of moderate strength, and had an average length of staple of five feet. The length of the ultimate fibre varied from 1·2 to 2·7 mm. (0·05-0·11 inch), with an average of 2·1 mm. (0·08 inch).

The results of the chemical examination of this fibre are given below, together with those of several samples of the fibre of *Agave rigida*, which have been examined in the Scientific and Technical Department of the Imperial Institute:—

—	*Agave* species.	*Agave rigida* fibre.			
		Sample from Saharanpur.	Sample from Bahamas.	Sample from Trinidad.	Sample from New South Wales.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	10·7	9·1	12·8	11·6	9·8
Ash...	1·7	0·8	4·4	1·0	1·6
α-Hydrolysis (loss) ...	10·0	8·6	12·0	11·7	13·0
β-Hydrolysis (loss) ...	12·6	15·1	16·1	13·5	15·0
Mercerisation (loss) ..	8·2	12·3	13·4	8·9	12·2
Acid purification (loss)...	1·0	1·6	8·1	1·0	5·6
Nitration (gain)	28·8	37·5	29·7	32·9	34·1
Cellulose	73·8	82·4	75·9	77·2	77·7

These figures show that the sample of fibre was on the whole, of good quality, and compared favourably with samples of *Agave rigida*. The comparatively small losses produced on hydrolysis and mercerisation proved that it was more resistant to the action of alkali than the other specimens, and was therefore likely to be more durable. On the other hand, the percentage of cellulose and the increase of weight on nitration were somewhat lower than those usually given by the fibre of *Agave rigida*.

The fibre was reported by one firm of fibre brokers to be of good length and colour, fairly well prepared, clean, fairly strong, similar to Sisal hemp, and worth from £26 to £28 per ton. A second firm, however, considered that its value was only £20 to £21 per ton.

Agave rigida. — This sample, labelled "*Agave rigida*, from Sambalpur District, Central Provinces," was of a pale buff colour and fairly strong but imperfectly cleaned. The length of its staple was about 4½ feet; that of its ultimate fibres varied from 1·3 to 2·2 mm. (0·05-0·09 inch), with an average of 1·6 mm. (0·07 inch).

The results of the chemical examination of this specimen are given in the following table, together with those of other samples

of the fibre of *Agave rigida* which have been examined in the Scientific and Technical Department of the Imperial Institute:—

—	Present Sample.	Sample from Saharanpur.	Sample from Bahamas.	Sample from Trinidad.	Sample from New South Wales.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	11·0	9·1	12·8	11·6	9·8
Ash...	3·6	0·8	4·4	1·0	1·6
α-Hydrolysis (loss) ...	19·6	8·6	12·0	11·7	18·0
β-Hydrolysis (loss) ...	21·9	15·1	16·1	13·5	15·0
Mercerisation (loss) ...	12·5	12·4	13·4	8·9	12·2
Acid purification (loss)...	2·5	1·6	8·1	1·0	5·6
Nitration (gain)	30·5	37·5	29·7	32·9	34·1
Cellulose	67·[illegible]	82·4	75·9	77·2	77·7

A comparison of these figures shows that the sample suffered an unusually large loss in the process of hydrolysis, the greater part of which occurred during the first five minutes (α-hydrolysis). The percentage of cellulose was correspondingly low. The comparatively poor quality of this specimen was no doubt largely due to the presence of gummy matter, owing to defective preparation. The results of this investigation indicated that the quality and value of this fibre could be considerably enhanced by the exercise of greater care in its extraction and preparation for the market.

The fibre was reported to be of good colour and fair length, harsh but fairly well cleaned. The commercial value of this material was estimated at from £15 to £18 per ton.

Furcræa gigantea.—A sample of *Furcræa* fibre, forwarded to the Imperial Institute by the Officiating Reporter on Economic Products to the Government of India, was labelled "*Furcræa gigantea*, from Sambalpur Jail, through the Superintendent of the Royal Botanic Gardens, Sibpur." The product was of a pale buff colour and of fair strength, but had not been well cleaned. The length of staple varied from 4½ to 5 feet.

On chemical examination it gave the following results, to which are added for comparison those yielded by other samples of this fibre which have been examined in the Scientific and Technical Department of the Imperial Institute:—

—	Present Sample.	Sample from Southern India.	Sample from British Central Africa.	Sample from Grenada.	Sample from Victoria.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	10·4	9·8	8·7	10·2	11·6
Ash	2·2	—	1·1	2·4	2·3
α-Hydrolysis (loss) ...	28·4	12·4	10·0	14·9	13·0
β-Hydrolysis (loss) ...	30·1	11·5	14·5	22·0	23·5
Mercerisation (loss) ...	16·8	11·4	8·7	16·0	16·2
Acid purification (loss)...	4·4	1·7	1·7	3·8	5·6
Nitration (gain) ...	26·6	40·7	38·1	34·0	34·0
Cellulose	66·9	77·7	75·8	77·8	72·2
Length of ultimate fibre	1·5-3·5 mm. or 0·06-0·14 in.	2-5 mm. or 0·08-0·2 in.	2-5 mm. or 0·03-0·2 in.	1-5 mm. or 0·04-0·[illegible] in.	1-3 mm. or 0·04-0·12 in.

These results indicate that the quality of this sample of *Furcræa* fibre was somewhat inferior to that of the other specimens. This was shown especially by the greater action exerted upon the material by alkali, as demonstrated by the loss of weight sustained in the processes of hydrolysis and mercerisation. The percentage of cellulose and the increase of weight on nitration, which were rather lower than in the other cases, point in the same direction. There can be little doubt that the comparatively poor quality of this sample was largely due to defective preparation. This conclusion was supported by the fact that the greater part of the loss of weight produced by the hydrolysis of the fibre took place in the α-hydrolysis, that is, during the first five minutes of its exposure to the action of hot alkali, and was due rather to the extraction of gummy matter—which ought to have been removed in the process of preparation—than to attack of the actual fibre substance. The further loss occasioned by the β-hydrolysis, which lasts for an hour, was comparatively small. It thus appeared probable that by the exercise of more care in the preparation of this fibre a considerable improvement in its quality and value could be effected.

In a trade report on this sample of fibre, it was stated that the product was soft, of fair colour, of good length, fairly strong, but not well cleaned, and worth from £18 to £20 per ton.

Agave species.—A sample of Indian Sisal hemp, representing commercial consignments of the fibre as sold in the London market, and stated to have been obtained from the Madras Presidency, was received for examination in 1905. It consisted of one large bundle and two smaller portions. The fibre composing the small portions was inferior in colour to that of the large bundle and, consequently, the sample for examination was taken entirely from the latter. The fibre possessed good strength, had a pale straw colour, and was lustrous. The length of staple ranged from 2 feet 9 inches to 3 feet.

The chemical examination gave the following results, for comparison with which the analyses of other samples are quoted:—

—	Present sample of Indian Sisal hemp.	Genuine Sisal hemp from the Bahamas.	Previous sample of Indian Sisal hemp.
	Per cent.	Per cent.	Per cent.
Moisture	8·4	12·8	11·0
Ash	3·0	4·4	3·6
α-Hydrolysis (loss)	26·2	12·0	19·6
β-Hydrolysis (loss)	27·1	16·1	21·9
Mercerisation (loss)	16·0	13·4	12·5
Acid purification (loss)	12·0	8·1	2·5
Nitration (gain)	23·0	29·7	30·5
Cellulose	67·3	75·9	57·1
Length of ultimate fibre ...	1·4–3·1 mm. 0·05–0·12 in.	— —	— —

From a consideration of these figures it is clear that this sample of Indian Sisal hemp was distinctly inferior to the true Sisal hemp from the Bahamas and slightly inferior to the previous sample of the same fibre from India. The percentage of cellulose in the Indian samples was much lower than in that from the Bahamas, whilst the loss on hydrolysis was greater. In the present sample of Indian Sisal hemp the loss on hydrolysis was very high, and on this account it appeared probable that the fibre would not be so durable as the true Sisal hemp. The loss on acid purification was also considerable, and suggested that the fibre had not been thoroughly cleaned.

Samples of *Agave* and *Furcræa* fibres were forwarded to the Imperial Institute by the Agri-Horticultural Society, Teynampett, Madras. It was stated that the plants had been grown at Madras, Bangalore, and Chickmagalur in the Kadur district, that is, at sea-level, and at 3,000 and 4,000 feet above the sea-level respectively. A description of the fibres and an account of the results of their investigation are given below.

Sample No. 1 (*Agave Vera-Cruz*).—This sample of *Agave Vera-Cruz* fibre from Chickmagalur, Kadur, was of a dirty white colour, and had not been well cleaned and prepared, but still retained some adherent green matter. The material was rather weak and irregular in strength, and varied in length from 3 to 4 feet.

The results of the chemical examination of this sample were as follows:—

	Per cent.
Moisture	9·1
Ash	2·5
α-Hydrolysis (loss)	19·8
β-Hydrolysis (loss)	21·4
Acid purification (loss)	5·7
Mercerisation (loss)	12·2
Nitration (gain)	39·1
Cellulose	71·4

From a comparison of these results with those obtained with other Indian specimens of *Agave* fibres examined in the Scientific and Technical Department of the Imperial Institute (see table on p. 99), it is evident that the present sample suffered considerable loss when boiled with dilute alkali (α- and β-hydrolysis). It is probable, however, that this loss was largely due to the extraction by the alkali of gummy matter which had not been removed during the preparation of the material, since the greater part of the loss took place during the first five minutes' boiling (α-hydrolysis), and the additional loss after an hour's boiling was comparatively small. It is probable that, if well prepared, the fibre would be of a good, durable quality. The proportion of cellulose in the fibre was somewhat low, but this, again, was no doubt due to the presence of the impurities already mentioned.

The commercial experts reported that the fibre was worth about £24 to £25 per ton, but that, if well prepared and thoroughly

cleaned, it would probably be worth from £26 to £28 per ton in the London market.

Sample No. 2 (*Agave Vera-Cruz*). This sample of *Agave Vera-Cruz* fibre from Madras had been badly prepared and incompletely cleaned, a good deal of green matter still remaining attached to it.

The material was of brownish colour, of rather poor strength, and had a length of staple varying from 3 feet 9 inches to 4 feet 5 inches.

On chemical examination the following results were obtained:—

	Per cent.
Moisture	9·1
Ash	3·4
α-Hydrolysis (loss)	19·5
β-Hydrolysis (loss)	21·6
Acid purification (loss)	4·5
Mercerisation (loss)	12·7
Nitration (gain)	38·0
Cellulose	72·5

These figures show that in chemical behaviour and composition this fibre closely resembled Sample 1, and the same conclusions may be drawn with regard to the quality of the product.

The commercial experts reported that the fibre was of inferior quality, had not been well cleaned, and was worth from £22 to £22 10s. per ton in the London market.

Sample No. 3. *Sisal Hemp.*—This sample of Sisal hemp from Madras consisted of pale straw-coloured lustrous fibre, which had been well cleaned, and was of fairly good but rather irregular strength. The length of staple varied from 3 feet 9 inches to 4 feet 3 inches.

On chemical examination the fibre furnished the following results:—

	Per cent.
Moisture	9·3
Ash	1·5
α-Hydrolysis (loss)	13·6
β-Hydrolysis (loss)	16·9
Acid purification (loss)	2·9
Mercerisation (loss)	10·8
Nitration (gain)	33·1
Cellulose	75·7

These figures show that the sample was of fairly good quality, although somewhat inferior to a specimen of Sisal hemp from Saharanpur (see table on p. 99). This inferiority was shown particularly in the greater loss sustained on hydrolysis and in the lower percentage of cellulose, and was probably mainly due to the sample not having been so well cleaned as that from Saharanpur.

The commercial experts reported that the fibre was fairly well cleaned, of medium length and fair colour, and worth from £29 to £30 per ton in the London market.

Sample No. 4. *Sisal Hemp.*—This sample of Sisal hemp from Lal Bagh, Bangalore, resembled sample No. 3, but was somewhat cleaner and rather coarser. The material was of good strength and had a length of staple 4½ to 5 feet.

The following are the results of the chemical examination of this sample:—

	Per cent.
Moisture	9·3
Ash	1·2
α-Hydrolysis (loss)	11·4
β-Hydrolysis (loss)	16·0
Acid purification (loss)	2·1
Mercerisation (loss)	8·4
Nitration (gain)	41·2
Cellulose	77·6

These results show that this fibre resembled the preceding sample of Sisal hemp, but was somewhat superior to it, especially in richness in cellulose. It was, however, inferior to the sample from Saharanpur referred to above.

The commercial experts reported that the fibre was of good quality, length and colour, and had been fairly well cleaned, but contained some hard, imperfectly prepared strands, and that it was worth £31 to £32 per ton in the London market.

Sample No. 5 (*Agave Wightii*).—This sample of the fibre of *Agave Wightii* from Madras consisted of lustrous, pale straw-coloured fibre which had been fairly well cleaned, but still retained a small quantity of adherent green matter. The material was of rather poor strength and had a staple 2 to 2½ feet long.

On chemical examination it yielded the following results:—

	Per cent.
Moisture	9·9
Ash	2·6
α-Hydrolysis (loss)	16·3
β-Hydrolysis (loss)	18·7
Acid purification (loss)	2·9
Mercerisation (loss)	10·9
Nitration (gain)	14·2
Cellulose	75·2

These figures show that the fibre was of fair quality, but rather susceptible to the action of alkali. The greater part of the loss in weight on hydrolysis was sustained, however, during the first five minutes' boiling (α-hydrolysis), and appeared to be due rather to the presence of gummy impurities which were not removed during the preparation of the material, than to the attack of the actual fibre substance. There can be no doubt that this product would be of good serviceable quality if more care were exercised in its preparation.

The commercial experts reported that the fibre was soft, of fair colour and fairly clean, but contained some coarse ends and hard, imperfectly prepared strands. The value of the material was estimated at £22 to £23 per ton in the London market.

Sample No. 6. Mauritius Hemp (*Furcræa gigantea*).—This sample of Mauritius hemp from Lal Bagh, Bangalore, was of a pale greenish-brown colour, and had been very imperfectly prepared. The product was fairly strong, and from 3 feet 6 inches to 4 feet 3 inches in length.

The results of the chemical examination were as follows:—

	Per cent.
Moisture	9·3
Ash	2·1
α-Hydrolysis (loss)	17·1
β-Hydrolysis (loss)	23·9
Acid purification (loss)	6·1
Mercerisation (loss)	12·0
Nitration (gain)	28·0
Cellulose	70·3

On comparing these results with those furnished by another Indian sample of *Furcræa gigantea* (see table below), it is apparent that the quality of the present sample was decidedly inferior. This was indicated by the greater losses sustained on hydrolysis and mercerisation, the smaller proportion of cellulose and the smaller increase of weight on nitration, and it was therefore considered probable that this sample would be less valuable and durable.

The commercial experts reported that the sample consisted of rather short and coarse fibre, which was of a poor, dull colour, had not been well cleaned, and was worth £23 to £24 per ton in the London market.

The results obtained in the chemical investigation of these six samples are collected together in the following table, to which are added, for convenience of comparison, the corresponding values given by other specimens of Indian *Agave* and *Furcræa* fibres previously examined in the Department.

—	Samples from the Agri-Horticultural Society.						Samples previously received.		
	No. 1. *Agave Vera-Cruz* from Chickmagalur.	No. 2. *Agave Vera-Cruz* from Madras.	No. 3. Sisal hemp from Madras.	No. 4. Sisal hemp from Bangalore.	No. 5. *Agave Wightii* from Madras.	No. 6. Mauritius hemp from Bangalore.	*Agave* species from India.	Sisal hemp from Saharanpur, India.	*Furcræa gigantea* from India.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	9·1	9·1	9·3	9·3	9·9	9·3	9·7	9·1	9·8
Ash	2·5	3·4	1·5	1·2	2·6	2·1	1·5	0·8	[illegible]
α-Hydrolysis (loss) ..	19·8	19·5	13·6	11·4	16·3	17·1	9·8	8·6	12·3
β-Hydrolysis (loss) ..	21·4	21·6	16·9	16·0	18·7	23·9	15·7	15·1	14·5
Acid purification (loss) ..	5·7	4·5	2·9	2·1	2·9	6·1	2·4	1·6	1·7
Mercerisation (loss) ..	12·2	12·7	10·8	8·4	10·[illegible]	12·0	7·1	12·3	11·4
Nitration (gain)	39·1	38·0	33·1	41·2	14·2	28·0	34·0	37·5	40·6
Cellulose	71·4	72·5	75·7	77·6	75·2	70·3	79·6	82·4	77·7

Experiments were made with the object of ascertaining the comparative strength of these fibres. For this purpose the break-

ing strain of single fibres (or filaments) of the material was deter mined, a large number of tests being made with each sample o: fibre. A great variation was found in the strength of the individual fibres (or filaments) of any particular sample corresponding more or less with the variation in their diameter. On taking the average of the results in each case, the comparative strength of the samples was found to be as follows, the greatest strength observed, viz., that of sample No. 4, being represented as 100:—

Sample.	Comparative strength.
No. 4. Sisal hemp	100
No. 3. ,, ,, ...	87·5
No. 6. Mauritius hemp	81·0
No. 2. *Agave Vera-Cruz* fibre	62·7
No. 5. *Agave Wightii* fibre	57·9
No. 1. *Agave Vera-Cruz* fibre	55·3

CONCLUSIONS.

The results of this investigation showed that the fibres, although of fair, marketable quality, could be considerably improved by the exercise of greater care in their preparation.

It was, unfortunately, impossible to ascertain the influence of the elevation at which the plants were grown on the strength and quality of the fibre produced, since the variation in the degree to which the samples had been cleaned was so considerable as to obscure the inherent quality of the actual fibre substance. In this connection it is interesting to notice that the commercial experts stated that the comparative market value of the various fibres of this class was very uncertain, as most of them had been very imperfectly cleaned, and that consequently the value was influenced to an unusual extent by the condition of the fibre.

Three samples of fibre derived from *Agave rigida*, *Agave americana*, and *Furcræa* species were forwarded by the Director of Agriculture, Madras, in 1907.

"No. 1, *Agave rigida*, hand-cleaned, plantation, Hindupur, Madras, age 6 years," consisted of well-prepared fibre of good lustre, varying in colour from nearly white to pale buff. The product was of very good strength and 3 feet long.

On chemical examination it gave the following results:—

	Per cent.
Moisture	9·0
Ash	1·5
α-Hydrolysis (loss)	11·5
β-Hydrolysis (loss)	14·6
Acid purification (loss)	2·0
Cellulose	73·0

The material was valued at £36 to £38 per ton (with Mexican "Sisal" at £34 per ton).

This fibre was of excellent quality, but it was pointed out that the value would be higher if the colour were more even and nearly white.

"No. 2, *Agave americana*, hand-cleaned, plantation, Hindupur, Madras, age 6 years," was of uneven quality. One bundle consisted principally of nearly white, lustrous fibre which had been fairly well cleaned, whereas the rest of the fibre was somewhat gummy, of poor lustre, and had a quantity of greenish pulp adhering to it. The product was of uneven strength and 2 to 3 feet long.

On chemical examination the following results were obtained:—

	Per cent.
Moisture	9·7
Ash	2·0
α-Hydrolysis (loss)	16·3
β-Hydrolysis (loss)	20·0
Acid purification (loss)	3·8
Cellulose	77·0

The product was regarded as worth £27 to £28 per ton (with Mexican "Sisal" at £34 per ton).

The greenish colour and the gummy and pulpy nature of the bulk of the sample were evidently due to insufficient washing. The staple was rather short for rope-making fibre. The material was obviously inferior to Sample No. 1, *Agave rigida*.

"No. 3, *Furcraea*, hand-cleaned, plantation, Hindupur, Madras, age 6 years," consisted of fairly well-cleaned fibre, better in this respect than No. 2, varying from buff to nearly white, of fair lustre, but a little gummy and stiff. It was of uneven strength and from 2 to 3 feet long.

On chemical examination it furnished the following results:—

	Per cent.
Moisture	10·0
Ash	1·5
α-Hydrolysis (loss)	18·8
β-Hydrolysis (loss)	22·1
Acid purification (loss)	3·0
Cellulose	72·0

The fibre was valued at £26 to £27 per ton (with Mauritius hemp at £24 to £30 per ton).

It was pointed out that this fibre would have been more valuable if it had been more even in colour and less gummy. The length of staple was poor for rope-making purposes. The loss on hydrolysis was rather great, but otherwise the sample was superior to many of the specimens of this fibre recently examined.

Sansevieria trifasciata.

A sample of the fibre of *Sansevieria trifasciata* was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products in 1903. It was stated that the product was received from a correspondent in Nazira, Assam, who desired a report on its commercial value and its chemical properties and composition.

The sample consisted of a well-prepared, white, glossy fibre with a staple of average length 4½ feet. The results of its chemical examination are given in the following table, together with those of samples of *S. zeylanica*:—

Sample of Sansevieria fibre from—	Moisture.	Ash.	α-Hydrolysis (loss).	β-Hydrolysis (loss.)	Mercerisation (loss).	Acid purification (loss).	Nitration (gain).	Cellulose.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nazira, Assam	9·0	0·6	10·0	12·6	8·1	2·3	31·3	74·4
Angoorie, Assam	9·4	0·7	11·8	14·9	11·6	1·4	33·5	75·9
Grenada	9·5	1·4	11·9	17·2	14·5	0·8	28·6	72·7
Straits Settlements	9·8	0·7	—	—	—	—	—	75·9

These results show that this sample was of very good quality, and was at least equal to, if not better than, the sample of *S. zeylanica* from Angoorie, Assam, which was favourably reported on in 1896 (Technical Reports and Scientific Papers of the Imperial Institute, p. 72). The losses sustained on hydrolysis and mercerising show that it was less liable to attack by alkali than any sample of *Sansevieria* fibre previously examined, and was therefore likely to be more durable.

Representative specimens of the fibre were submitted to two leading firms of brokers for valuation. It was reported that the fibre was of *first-class* quality, superior to that usually seen on the London market, and would meet with a ready sale. One firm stated that the value at that time was from £50 to £55 per ton in quantities of ten tons and upwards, but that small lots were of lower value. The other firm valued the sample at £33 per ton.

From the foregoing report it is clear that the fibre was of excellent quality. In view of the favourable opinions expressed by the experts with regard to this sample, it seemed desirable that the proposal to place an experimental shipment on the London market should be carried into effect. It was stated that the Imperial Institute would be glad to be informed as to whether there was any prospect of a regular supply of this fibre.

CEYLON.

Musa sapientum.

A sample of plantain fibre (*Musa sapientum*) forwarded by the Ceylon Agricultural Society in 1907 consisted of two portions: (1) Brown, coarse fibre, badly cleaned, without lustre, and of poor and uneven strength; (2) fine, buff-coloured fibre, fairly well cleaned, but limp and of uneven and rather poor strength. The former had a length of about 4 feet, and the latter a length of about 3 feet 3 inches. Portion (1) was of little or no commercial value, but (2), if of good strength and lustre, would probably have been worth from £30 to £40 per ton. The small portion (2) was better prepared than (1), and would have been of marketable

quality if it had not been so weak. It was considered possible that the weakness in this case might have been due to insufficient washing and drying of the fibre after extraction.

STRAITS SETTLEMENTS.

Musa species.

Two samples of fibre were forwarded to the Imperial Institute by the Director of the Botanic Gardens at Singapore in 1906.

One of these samples was derived from the wild plantain, *Musa malaccensis*, which is very abundant in the Straits Settlements, and could be grown as a catch crop with rubber if the fibre proved to be of value. The other fibre was obtained from a cultivated banana, *Musa sapientum*, of the common edible variety known as "Rastali."

Description of Samples.

The sample obtained from *Musa sapientum*, var. *Rastali*, consisted of rather coarse and imperfectly cleaned fibre, light buff in colour, and of very poor strength. The average length was 5 feet 6 inches, but some of the fibre was as much as 7 feet in length. The sample from *Musa malaccensis*, the "Wild Pisang," consisted of one ounce of very weak fibre averaging 6 feet 7 inches in length, some of the fibre being 9 feet long. It was inferior to the other fibre in appearance, and was also coarser owing to the fact that the fibres had not been separated to the same extent. The coarseness and weakness of the fibres were most likely due to imperfect cleaning and preparation.

The samples were submitted to commercial experts, who reported that the *Musa sapientum* fibre was a well-grown fibre of good length, but totally lacking in strength, which is the most important quality required in fibre for rope-making. In view of the high prices then ruling for fibres it was valued at £28 per ton (July, 1906).

The fibre of *Musa malaccensis* was described as a well-grown fibre of satisfactory colour, but much drier and more brittle than Manila hemp. The value was estimated at about £35 per ton, but if the fibre was of greater strength the value would be £6 to £7 per ton more.

These fibres appeared to have been well grown, but not very satisfactorily prepared. The fibre from the wild plant, *Musa malaccensis*, was the more promising. If greater care were taken in the extraction process so as to obtain properly separated fibres of greater strength the products would meet with a satisfactory sale.

Sansevieria zeylanica.

An inquiry relating to the value of samples of "Murva" fibre, grown experimentally in the Straits Settlements, was referred to the Imperial Institute by the Commercial Department of the Board of Trade in 1903.

The sample which was first forwarded only weighed 2·6 grams and is stated to have been extracted from a single leaf. It had a

white, lustrous appearance and a staple of about 50 cm. (20 inches). A second sample was afterwards received, which was very similar in character and appearance to the first, except that it had a very slight yellowish tinge.

Owing to the small amount of fibre available, a complete chemical examination could not be carried out, but the following determinations were made by the usual methods. For comparison, the results furnished by the examination of other specimens of the fibre of *Sansevieria zeylanica* by the Scientific and Technical Department of the Imperial Institute are also quoted:—

—	Moisture.	Ash.	Cellulose.	Length of ultimate fibre.
	Per cent.	Per cent.	Per cent.	
Straits Settlements	9·9	0·7	75·9	1–3 mm.
Grenada	9·5	1·4	72·7	1–5 mm.
Assam	9·4	0·7	75·6	1·5 3·5 mm.

From these results it appears that the fibre from Selangor was fully equal in quality to specimens obtained from other sources.

The fibre was submitted for commercial valuation to two leading firms of fibre brokers, who were informed of the favourable results which it had furnished on chemical examination. One firm reported that the sample was a very strong, clean, hard fibre, of good colour, but rather short and tapering; it was coarser, and not quite so soft and pliable as is usual for the fibre of *Sansevieria zeylanica*. It was stated that owing to the want of regular supplies the fibre had not a recognised position on the London market, but consignments of long staple have been sold at very high prices. The value of the specimen was given as about £35 per ton (with Sisal hemp at £37 per ton), but if long and of similar quality it would have been worth £40 per ton and upwards.

The other brokers to whom the fibre was submitted valued it at £33 per ton, and £36 per ton if "bright white," at which prices they stated it would meet with ready sale.

It would appear from these reports that these samples of fibre of *Sansevieria zeylanica* were of good quality, and that consignments of similar character would probably meet with a ready sale on the London market.

SOUTH AUSTRALIA.

Samples of Sisal hemp, bowstring hemp, and Mauritius hemp were forwarded in 1908 by the South Australia Chamber of Manufactures (Incorporated) to the Commercial Intelligence Branch of the Board of Trade, and were transmitted to the Imperial Institute for examination and valuation. The samples were too small to admit of a complete chemical examination being carried out

Agave rigida var. *sisalana.*

This sample of Sisal hemp consisted of white, strong fibre with a staple of average length 40 inches. On chemical examination it furnished the following results:—Moisture, 8·8 per cent.; ash, 0·7 per cent.; cellulose, 79·1 per cent. A comparison of these results with those yielded by specimens of Sisal hemp cultivated in other Colonies is given in the following table:—

Source.	Moisture.	Ash.	Cellulose.
	Per cent.	Per cent.	Per cent.
South Australia	8·8	0·7	79·1
Bahamas	12·8	4·4	75·9
Trinidad	11·6	1·0	77·2
New South Wales	9·8	1·6	77·7
India (Saharanpur)	9·1	0·8	82·4

From these figures it is seen that the present specimen furnished a low proportion of ash and a high proportion of cellulose; it was, therefore, of good quality and likely to be durable.

The brokers reported that the fibre was of good length and colour, fairly strong, and worth from £35 to £38 per ton on the London market.

Sanseviera zeylanica.

This specimen of bowstring hemp was clean, of good colour, and had an average length of 38 inches. It yielded the following results on chemical analysis:—Moisture, 8·1 per cent.; ash, 0·4 per cent.; cellulose, 80·9 per cent. In the following table these results are compared with those furnished by specimens of this fibre grown in other Colonies:—

Source.	Moisture.	Ash.	Cellulose.
	Per cent.	Per cent.	Per cent.
South Australia	8·1	0·4	80·9
Assam...	9·4	0·7	75·6
Grenada	9·5	1·4	72·7
Straits Settlements	9·9	0·7	75·9

These numbers show that the sample yielded a very low percentage of ash, and contained an unusually large proportion of cellulose, and on these grounds was regarded as of good quality.

The brokers reported that it was a soft, fine fibre, but somewhat deficient in strength, and of the value of £33 to £35 per ton.

Furcræa gigantea.

This sample of Mauritius hemp was of fair colour, but had not been so carefully prepared as the two preceding samples; its staple

was about 5 ft. in length. The results obtained on chemical examination were as follows:—Moisture, 8·5 per cent.; ash, 1·4 per cent.; cellulose, 74·5 per cent. In the following table these figures are compared with those yielded by specimens of Mauritius hemp from other countries:—

Source.	Moisture.	Ash.	Cellulose.
	Per cent.	Per cent.	Per cent.
South Australia	8·5	1·4	74·5
Southern India	9·9	—	77·7
Grenada	10·2	2·4	77·8
Victoria	11·6	2·3	72·2
British Central Africa ...	8·7	1·1	75·8

In this case the cellulose was somewhat below the average, and, on this account, the fibre was probably of a less durable character. The brokers reported that the fibre was very long, but of poor colour, roughly prepared and weak. Its value on the London market was from £28 to £30 per ton.

JAMAICA.

Yucca aloifolia.

A sample of fibre of the "Dagger Plant" (*Yucca aloifolia*) was forwarded to the Imperial Institute in 1901 for examination and commercial valuation from Kingston, Jamaica. It was stated that the plant grows abundantly in certain districts of Jamaica, where the fibre is extracted by the peasantry, and that a sample of the fibre was valued in England in 1885 at £16 to £20 per ton.

The present sample consisted of a tangled mass of fibre of a yellowish or pale buff colour. It was somewhat brittle and not very strong. The staple was of irregular length, varying from about 6 to 20 inches. On examination the following results were obtained:—

	Per cent.
Moisture	9·8
Ash	1·7
α-Hydrolysis (loss)	21·4
β-Hydrolysis (loss)	27·3
Mercerisation (loss)	8·2
Acid purification (loss)	5·0
Nitration (gain)	38·4
Cellulose	70·1
Length of ultimate fibre	1-3 mm.

These results indicate that the sample was of an inferior character, very susceptible to attack by alkalis, and that it would probably not be very durable.

A representative specimen of the material was submitted to a firm of brokers for commercial valuation. They reported that, owing to the faulty preparation of the fibre, it was in the condition of tow, and worth only from £7 to £8 per ton, but that if it were properly prepared and cleaned, its value in the London market would be about £20 per ton.

It was suggested that a further sample of this product, more carefully prepared, should be forwarded for further investigation.

Abyssinia.

Musa species.

A sample of rope of native manufacture was included in a collection of Abyssinian products which was forwarded to the Imperial Institute by the Sudan Agent at Cairo in 1905.

The rope was fairly well made, but was of somewhat uneven diameter. As rope, it was of little interest here, but the fibre of which it was composed appeared to be of good quality, and it was therefore thought desirable to examine it. A portion of the rope was accordingly untwisted, and the fibre was examined with the following results:

The fibre was fairly fine, soft and lustrous, but of somewhat inferior strength. It had been well cleaned and prepared, and was pale buff in colour with some light brownish stains. From the general appearance of the fibre it seems probable that it is derived from a species of *Musa*.

The following table gives the results of the chemical examination of this fibre, together with those obtained with other *Musa* fibres from East Africa for comparison:—

—	Fibre from Abyssinia.	Fibre of *Musa Ensete* from German East Africa.		Banana fibre from East Africa Protectorate.	
		1st quality.	2nd quality.	No. 11,550.	No. 11,252.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ...	8·2	9·7	9·4	10·3	10·4
Ash ...	3·4	1·5	1·7	4·8	2·2
α-Hydrolysis (loss) ...	21·0	10·3	13·0	15·8	20·1
β-Hydrolysis (loss) ...	29·0	15·1	18·3	26·8	24·0
Acid purification (loss) ...	9·0	0·8	3·7	5·1	5·8
Cellulose ...	69·8	78·1	74·5	73·4	74·4
Length of ultimate fibres ...	3·2–6·6 mm. Mean 4·18 mm.	2·6–5·9 mm. Mean 3·8 mm.		—	—

The above figures show that the fibre from Abyssinia was inferior to the other fibres with which it was compared. The percentage of cellulose was low, and the loss on hydrolysis rather high, indicating that the fibre would probably be affected by exposure to moisture.

The fibre of which the rope was made appears on the whole to be of sufficiently good quality to find a sale in this country and it was suggested that, if the product was available in quantity, a larger sample might be forwarded so that it could be submitted to experts for valuation. It was pointed out that the fibre intended for export should, if possible, have a length of at least 4 feet, and be well cleaned and prepared.

German East Africa.

Musa species.

Attempts have been made during recent years in German East Africa to utilise two species of Musa, *M. Ensete* and *M. ulugurensis*, for the production of fibres, and, in view of the interest which this subject might have for planters in the adjacent British Protectorates, samples of these fibres have been examined at the Imperial Institute. The specimens were supplied through the Foreign Office and H.M. Consul at Zanzibar, by Professor Zimmermann, Director of the Biological and Agricultural Institute at Amani, who also furnished the following particulars regarding the fibres.

The fibres are prepared by the natives in a very primitive manner, but samples from each species which were forwarded to Germany in 1903 were reported by experts to be of very good quality, though inferior to true Manila hemp. The plants do not produce suckers, and therefore can only be propagated from the seeds, which in both cases germinate fairly easily. The yield of fibre from *Musa ulugurensis* is small in comparison with that from *Musa textilis*, the Manila hemp plant, but it is possible that this disadvantage may be compensated by the more rapid growth of the former plant, and by cheaper labour and improved methods of fibre extraction.

The samples of fibre were examined in the Scientific and Technical Department of the Imperial Institute, and were submitted to commercial experts for valuation.

The samples of *Musa Ensete* fibre were of two qualities. The sample marked "first quality" consisted of nearly white or pale straw-coloured fibre, which was of lustrous appearance and good strength, and had been well prepared. The length of staple was 5½ to 6 feet.

The sample marked "second quality" was of a darker colour than the previous sample and slightly inferior in strength. The staple was from 4 to 4½ feet long.

The sample of *Musa ulugurensis* fibre resembled the *Musa Ensete* fibre in appearance, but was less lustrous and harsher to the touch.

The results of the chemical examination of these samples of fibre are given in the following table. There are no results of any previous investigation of these fibres available for comparison, for although *Musa Ensete* grows in Jamaica, and some experi-

ments on the extraction of the fibre were carried out many years ago, no chemical examination was recorded.

—	*Musa Ensete.* 1st Quality.	*Musa Ensete.* 2nd Quality.	*Musa ulugurensis.*
	Per cent.	Per cent.	Per cent.
Moisture	9·7	9·4	10·2
Ash	1·5	1·7	1·6
α-Hydrolysis (loss) ...	10·3	13·0	22·9
β-Hydrolysis (loss) ...	15·1	18·3	24·7
Mercerisation (loss) ...	11·0	12·7	17·9
Acid purification (loss) ...	0·8	3·7	6·5
Nitration (gain)	36·5	26·3	37·4
Cellulose	78·1	74·5	70·7
Lenght of ultimate fibre ...	2·6–5·9 mm. (0·10–0·23 in.) Average length 3·8 mm. (0·15 in.)		2·2–4·7 mm. (0·08–0·18 in.) Average length, 3·1 mm. (0·12 in.)

These figures show that the samples of *Musa Ensete* fibre were rich in cellulose, fairly resistant to the action of alkali—as shown by the results of hydrolysis and mercerisation—and contained but a small proportion of adventitious impurity, as indicated by the results of the ash and acid purification determinations. In all these respects the sample marked "first quality" was superior to that marked "second quality." The fibre was doubtless of considerable value and would probably prove a very durable material.

The results also demonstrated that the sample of *Musa ulugurensis* fibre was decidedly inferior to those of *Musa Ensete* in all points referred to above, and would consequently be less durable.

The commercial experts to whom the fibres were submitted reported that they were of very promising quality. The "first quality" of *Musa Ensete* was stated to be of good bright colour, well cleaned, readily saleable in the London market and probably worth about £50 per ton. The "second quality" was considered to be inferior in colour but of good quality, and worth £45 per ton. The fibre of *Musa ulugurensis* was regarded as a very useful material but inferior to that of *Musa Ensete;* its value was estimated at £40 per ton. These valuations were based on the expectation that no special difficulty will be encountered when the fibres are worked by machinery in manufacturing processes.

The results of this investigation showed that these East African *Musa* plants would no doubt prove well worth cultivating for the sake of their fibre, which, if carefully prepared, would obtain a ready sale at good prices. It was stated in the Official Report on the British East Africa Protectorate for 1903-1904 (Cd. 2331), that a wild banana plant which produces an excellent fibre grows in several districts of the Protectorate. It was suggested that possibly this plant might be one of the species of *Musa* referred to.

Steps were therefore taken to identify the plant and prepare samples of fibre for examination at the Imperial Institute. The results of these investigations have already been described on pages 61-64.

LIBERIA.

A sample of fibre from Liberia, forwarded in 1904 to the Commercial Intelligence Branch of the Board of Trade by H.B.M. Consul at Monrovia, was transmitted to the Imperial Institute for examination. The fibre was obtained from plants growing in the neighbourhood of the port of Sino, but no information was available regarding its botanical source.

The sample consisted of a number of small bundles knotted at one end, the average length of staple being 2 feet 6 inches. It was evidently a leaf fibre, and may possibly have been derived from a species of *Agave*. The fibre was dry and harsh and varied in strength, some portions being good and others deficient in this respect. It possessed a slight greenish colour, and in addition the bundles contained a few reddish-brown strands. There is little doubt that the fibre was insufficiently prepared, and more careful treatment would probably considerably improve its colour and quality.

The chemical examination of the fibre furnished the following results, for comparison with which the figures given by a sample of Sisal hemp from the Bahamas are also quoted. It may be mentioned that the fibre from Liberia was partially cleaned by hackling before analysis.

	Fibre from Liberia. Per cent.	Sisal Hemp from the Bahamas. Per cent.
Moisture ...	10·4	12·8
Ash ...	2·0	4·4
α-Hydrolysis (loss) ...	21·7	12·0
β-Hydrolysis (loss) ...	24·2	16·1
Mercerisation (loss) ...	9·2	13·4
Acid purification (loss) ...	2·8	8·1
Nitration (gain) ...	32·0	29·7
Cellulose ...	73·5	75·9
Length of ultimate fibre ...	1·2-1·9 mm. or 0·058-0·076 in.	

These figures indicate that, so far as chemical composition is concerned, this fibre from Liberia was of very fair quality, and compared favourably in most respects with the sample of Sisal hemp from the Bahamas. It was distinctly inferior to the latter, however, in the great loss on hydrolysis, and this fact suggested that it might not be so durable as true Sisal hemp when exposed to the action of weak alkalies or water. The fibre might probably be improved in this respect by more careful preparation.

This fibre from Liberia belonged to the class chiefly utilised for rope-making, but owing to its short length it would only realise

a moderate price for this purpose. Brokers to whom the present sample was submitted valued it at £16 to £18 per ton in London, but stated that if the fibre were well cleaned the price per ton would probably be increased by a few pounds.

BRAZIL.

"*Caruá*" *and* "*Makimbeira*" *Fibres.*

Samples of these fibres were forwarded by the British Consul at Bahia to the Foreign Office, and were transmitted to the Imperial Institute for chemical examination and commercial valuation. The specimens were accompanied by a memorandum from the Consul, which contained the following particulars relating to their origin and mode of preparation.

Caruá fibre is stated to be derived from a plant which is common in the northern parts of the State of Bahia, and thrives best at high altitudes. The extraction of the fibre is carried out by the natives in the following manner. After the stems have been cut the outer bark is removed, and the rough fibre is retted by steeping it in water for fifteen days, and is afterwards scraped with a blunt knife. The green fibre thus obtained is dried and twisted into ropes, which hitherto have only been employed locally. The preparation of this fibre by machinery was commenced by a British firm, and it was expected that large samples of the properly prepared material would shortly be available. It was also stated that experiments were being carried out on the cultivation of the plant.

Makimbeira fibre is derived from a plant which is closely allied to Caruá, and grows abundantly in proximity to it. This fibre is of a softer quality than that of Caruá.

The samples submitted were as follows:—

No. 1. Caruá fibre, prepared by natives, hulk and pulp removed. A white, fairly strong fibre, but not well prepared. Length of staple about 6 ft.

No. 2. Hand-made rope from green Caruá fibre.

No. 3. Makimbeira fibre prepared by natives, cuticle and pulp partially removed. In its general appearance this sample, which was very small, closely resembled No. 1.

A portion of the Caruá fibre (sample No. 1) was cleaned as far as possible by hackling, and was submitted to chemical examination with the following results:—

	Per cent.
Moisture	8·4
Ash	3·1
α-Hydrolysis (loss)	25·6
β-Hydrolysis (loss)	33·7
Acid purification (loss)	15·3
Mercerisation (loss)	23·5
Nitration (gain)	17·3
Cellulose	69·8
Length of ultimate fibre	2-5 mm.

This fibre contained little or no ligno-cellulose, which w shown especially by the pale colour of the nitration product and l the fact that when the chlorinated product obtained in the cour of the estimation of cellulose was acted on with sodium sulphit only a faint pink coloration was produced. The considerable loss sustained by the fibre on hydrolysis and mercerising showed th it was very sensitive to attack by alkali, and was, therefore, n likely to be so durable as some other fibres.

The sample of Makimbeira fibre was too small to admit chemical examination.

The samples were submitted to fibre brokers, who agreed stating that though of good length and fair colour they were irr gular in strength as the result of faulty preparation, and for th reason the fibres in their present state were only suitable for admi ture with better materials for the manufacture of cordage. Tl Caruá fibre was valued at from £10 to £13 per ton, and the han made rope, which appears to have been prepared from select fibre, at £25 per ton. The Makimbeira fibre was stated to l worth from £13 to £20 per ton.

From the foregoing report it is evident that, if better prepare these fibres might be of some commercial value, especially if constant supply of average quality could be maintained.

Confirming this opinion, information was received at a lat date that a consignment of dressed Caruá fibre had recent realised the price of £31 per ton in public auction in London.

Since the botanical origin of these fibres was not definite known, application was made to the Consul at Bahia for specime of the plants from which they are derived in order that the identity might be determined. These plants were received in d course and were transmitted for identification to the Roy Gardens, Kew.

It was stated that both plants belonged to the pineapple orde *Bromeliaceæ*, that plants of this order abound in many parts South America, and their fibres appear to be employed locall but whether these have any commercial value has yet to be asce tained. The Caraguatá, produced by *Bromelia argentina*, whi is abundant in the Argentine Republic and in Paraguay, is a ca in point. Some account of it is given in the "Collected Pape on Vegetable Fibres from the Kew Bulletin," 2nd ed., pp. 110-11 The Caruá, or more correctly, Caroá fibre, is said to be produc by *Neoglaziovia variegata*, Mex. The Makimbeira is probably allied species, but this could not be accurately determined owi to the absence of flowers on the specimen submitted f identification.

Hibiscus radiatus.

A sample of the fibre of *Hibiscus radiatus*, forwarded fro Brazil and labelled "Canhamo brasiliensis, Perini, Type B, II 130 days cultivation," consisted of a pale, buff-coloured lustro fibre which was rather harsher and somewhat weaker th European hemp, and had not been very well cleaned, so

portions being rather "gummy." The fibre was mostly about 4 feet to 4 feet 6 inches long, and varied up to 6 feet. The length of the ultimate fibres was from 2·6 to 6·6 mm. (or 0·10 to 0·26 inch) with an average of 3·6 mm. (or 0·14 inch). In this respect the product closely resembled jute, as would naturally be expected in the case of a fibre of the *Hibiscus* group, but differed considerably from hemp, the ultimate fibres of which vary from 5 to 55 mm. (or 0·2 to 2·2 inches), with an average of about 20 mm. (0·8 inch).

Commercial experts reported that this "Canhamo" fibre could be employed for mixing with Italian or French hemp, and would be worth about £26 to £27 per ton. On the date of this valuation Italian P.C. hemp was quoted at £44 to £45 per ton, and Polish hemp at £34 to £37 per ton.

MISCELLANEOUS FIBRES.

FLOSSES OR "SILK-COTTONS."

The flosses or "silk-cottons" are fine, soft, lustrous materials consisting of the seed-hairs of certain plants. The most valuable of these products is "kapok," derived from *Eriodendron anfractuosum*, and produced principally in Java, and to a small extent in India. "Kapok" is used chiefly for stuffing cushions, pillows, chairs, mattresses, and other articles, and is specially adapted for this purpose on account of its very resilient nature. Other uses have been suggested, however, and an account of these has been given in the *Bulletin of the Imperial Institute* (1905, **3**. 222-225).

UGANDA.

Bombax species.

A sample of silk cotton was forwarded to the Imperial Institute by the Acting Commissioner of Uganda in 1906, which was stated to have been derived from a tree which occurs frequently in Unyoro and is common in the Bugoma Forest. Botanical specimens had been forwarded to the British Museum, whence it was ascertained that the plant is a species of *Bombax*, probably *Bombax buonopozense*.

The floss was soft and very lustrous, of pale, buff colour and well cleaned, but of rather poor strength. The fibres varied in length from 0·7 to 1·0 inch, and had a diameter varying from 0·0006 to 0·0016 inch, with an average of 0·00112 inch.

Microscopical examination showed that the fibres consisted of long, flat, unicellular hairs, which were hollow, and had very thin walls. They were very smooth, devoid of surface markings, and tapered at both ends.

A chemical examination of the floss yielded the following results, for comparison with which the figures obtained for samples

of "kapok," the floss of *Eriodendron anfractuosum*, have been added.

	Present Sample.	Seychelles Kapok.	Java Kapok.
	Per cent.	Per cent.	Per cent.
Moisture	10·8	10·0	10·9
Ash (on the dry fibre)	0·8	2·1	1·3
Cellulose (on the dry fibre)	63·5	61·3	63·6

It will be seen that this floss was very similar in composition to the "kapok" of commerce.

The Uganda floss was equal in resiliency and length of fibre to a standard sample of "kapok." It would have similar commercial applications as an upholstery material, and if clean and in good condition would probably be worth about 5d. per lb. in England.

West Africa.

Eriodendron anfractuosum.

Southern Nigeria.—In February, 1906 a sample of kapok was forwarded to the Imperial Institute from Lagos with a request for a report on its quality and value. It was explained that the product was discoloured and dusty through having lain on the ground after falling from the trees.

The fibre was darker in colour than ordinary commercial kapok, but otherwise possessed the usual characters, being straight, soft and silky, resilient, and of poor strength. The diameter of the fibres varied from 0·00033 inch to 0·0012 inch with an average of 0·00075 inch.

The following table includes the results of the chemical examination of the present sample and also of two other samples of kapok for comparison:—

	Present sample from Lagos.	Genuine Java Kapok.	Kapok from Seychelles.
	Per cent.	Per cent.	Per cent.
Moisture	9·9	10·9	10·0
Ash	2·8	1·3	2·1
Cellulose	50·3	63·6	61·3

It will be seen from the above figures that the Lagos kapok contains a lower percentage of cellulose and a higher percentage of ash than either of the others.

The sample was valued by brokers at $3\frac{1}{4}d.$ per lb. in London, the price of best quality, machine-cleaned Calcutta kapok being $4\frac{1}{8}d.$ per lb. at the same time. The Java and Indian kapoks, which form the bulk of the present supplies, are fairly white, and it might be a little difficult at first to substitute a brown kapok

like the Lagos sample. The brokers, however, were of opinion that the product would probably sell freely provided that regular and sufficient supplies could be assured.

This kapok from Lagos was inferior in commercial value to Java and Indian kapok, owing to its darker colour, and to the fact that it was weather-beaten and stained. It was recommended that the seeds should be removed before export.

Gold Coast.—This was a specimen of clean fibre, free from seeds, of dull greyish-brown colour and good lustre, soft and silky, but somewhat "felted" and not very resilient.

The fibres possessed the usual characteristics of kapok. They were from 0·8 inch to 1·1 inch long, and 0·0006 to 0·0011 inch in diameter, the average diameter being 0·0008 inch.

This sample was inferior in colour to good commercial kapok, was also less resilient, and would probably be not worth more than 4*d.* per lb. in London. The condition of a portion of the sample suggested that it had been allowed to lie on the ground for some time and become soiled and weather-beaten before being collected.

Funtumia elastica.

Gold Coast.—In 1904, samples of the seed-floss and fruits of *Funtumia elastica*, Stapf, were forwarded to the Imperial Institute from the Gold Coast Colony. It was stated that large quantities of the fibre are available during the months of October and November, and it was desired to ascertain whether the material possesses any commercial value.

The floss was composed of fine silky hairs of a pale, reddish-brown colour and of good length, mostly from 1½ to 2½ inches, but was very weak and lacking in resiliency.

On chemical examination it gave the following results:—

	Per cent.
Moisture	14·7
Ash	3·7
Cellulose	56·4

A representative specimen of the product was submitted to a firm of fibre brokers, who reported that it was of poor quality and not well adapted for use in upholstery or for any other purpose to which the somewhat similar fibre known as "kapok" is applied. The opinion was expressed that the material was not likely to meet with a ready sale in the London market, and was of uncertain value, but, perhaps, might realise 1*d.* per lb., a price which, after deducting the cost of collection and transport, would probably be unremunerative.

SEYCHELLES.

Eriodendron anfractuosum (?).

This material, received in 1906, was labelled "Sample of kapok, Mahé, Seychelles," but no information was given regarding its botanical origin. It was a light silky floss of pale cream

colour, and contained some small particles of woody material and a few seeds, the latter resembling those of the tree *Eriodendron anfractuosum*, which yields genuine kapok.

The floss was chemically examined in comparison with a commercial specimen of genuine Java kapok, and the following results were obtained:—

	Seychelles kapok.	Java kapok.
	Per cent.	Per cent.
Moisture	10·0	10·9
Ash (on dry fibre) ...	2·1	1·3
Cellulose (on dry fibre) ..	61·3	63·6
Length of fibres.	0·75 inch	—

These figures indicate that in composition, as in appearance, the kapok from Seychelles closely resembles the product from Java, and, as *Eriodendron anfractuosum* occurs in the islands, it is probably derived from the same tree. There is no doubt that material represented by this sample could be utilised commercially for the same purposes as Java kapok.

A sample was submitted for valuation to commercial experts, who reported that the material was of very nice quality, but pointed out that it should be thoroughly freed from the seeds and fragments of pod before exporting to this country. It was valued in 1906 by manufacturers at 4d. to 4½d. per lb., but similar material if properly cleaned would probably realise ½d. per lb. more. The usual price of Java kapok in the London market is from 4d. to 5d. per lb.

INDIA.

Samples of Indian vegetable flosses were forwarded by the Officiating Reporter on Economic Products to the Government of India with a request that they might be examined and their commercial value ascertained.

Description of Specimens.—The specimens forwarded for examination were as follows:—

No. 1.—"Pod of *Eriodendron anfractuosum*."

No. 2—"Pod of *Cochlospermum Gossypium* from Bundelkhund, United Provinces."

These pods would possess no commercial value in this country, since it would not prove remunerative to extract the floss in Europe.

No. 3.—Registered No. 17,742—1. "Floss from *Cochlospermum Gossypium* from Bundelkhund, United Provinces."

This floss was of a dirty cream colour and contained a small quantity of seed. It was aggregated into flocks and was harsh and only slightly resilient. The staple was irregular in length but, on the whole, very short.

No. 4.—Registered No. 19,553. "Floss from *Cochlospermum Gossypium* from United Provinces."

This material resembled No. 3, but contained a larger proportion of seeds and fragments of leaves. The staple was very irregular in length.

No. 5.—Registered No. 19,397. "Floss from *Calotropis gigantea* from Kishengarh, Jaipur."

This material had a pale cream colour, and was fairly clean, containing only a few fragments of fruit. It had a brilliant gloss and was softer and more resilient than any of the other specimens. Its staple was irregular and varied in length from 25 to 35 millimetres (1·0 to 1·4 inches).

Chemical Examination.—The three flosses were chemically examined in the Scientific and Technical Department of the Imperial Institute and the results so obtained are given in the following table, which contains for convenience of comparison the results yielded by a sample of Java "kapok," and also by a specimen of the floss of *Calotropis procera* which was examined in the Department in 1897:—

Registered No. of Specimen.	Origin.	Moisture.	Ash.	Cellulose.
		Per cent.	Per cent.	Per cent.
17,742—1	Cochlospermum Gossypium	10·2	3·15	46·3
19,553	Cochlospermum Gossypium	10·0	4·4	45·9
19,397	Calotropis gigantea ...	9·3	2·7	64·3
	Java "kapok"	10·9	1·3	63·6
	Calotropis procera... ...	9·0	3·0	69·8

A comparison of these figures shows that the samples of *Cochlospermum* floss are decidedly inferior to the Java "kapok" and *Calotropis* flosses with regard to the amount of cellulose which they contain. The *Calotropis gigantea* fibre is equal to the "kapok" in this respect, whilst the *Calotropis procera* is somewhat richer in cellulose. All these flosses, however, contain a much smaller proportion of cellulose than cotton, which under similar conditions yields from 95 to 96·5 per cent. Their deficiency in this constituent accounts for their poor tenacity, and it is possible that even if the mechanical difficulties encountered in spinning such materials were overcome, the resulting fabrics would deteriorate so rapidly that no demand for them could be maintained.

Of the Indian flosses now under examination, only one—No. 19,397—was considered at all likely to be suitable for textile purposes, and it was submitted to an expert for technical trial. The expert reported that the floss was composed of straight, non-adherent fibres which were finer than those of good quality cotton, and that the material was too slippery and fluffy to be spun alone, but that it might be spun in admixture with cotton or wool, and that a fabric so prepared might for a time attract attention as a novelty.

The Indian flosses were, with the exception of No. 19,397, not nearly so soft and resilient as Javanese "kapok." Attention has

frequently been drawn to a similar defect in commercial Indian "kapok," and this has usually been regarded as being due to the material having been too highly compressed in order to lessen freight charges. In the present specimens, however, the inelastic character could not have been due to this cause, but had probably been produced by beating the floss in order to remove the seeds. It is stated that in Java a form of cotton gin has been successfully used for freeing the "kapok" from seeds, and doubtless the commercial value of these Indian flosses as upholstery materials would be enhanced if they were cleaned by such a process, instead of by the crude method of beating out the seeds now employed.

The results of the investigation of these Indian flosses show that these products are, on the whole, inferior to the "kapok" produced in Java, but that in view of some of the uses to which "kapok" and its substitutes are now being applied, it is quite likely that a market would be found for them at lower rates than those obtainable for the Javanese material. It was pointed out, however, that silk flosses of this kind are very widely distributed, and since attempts are being made at the present time to create an export trade in these products in South America and in various parts of Africa, notably Madagascar, the market is likely to be overstocked in the near future, and the prices realised for these materials will be small.

Madagascar.

Eriodendron anfractuosum.

A sample of silk-cotton was forwarded to the Imperial Institute in 1906 by the Acting Director of Agriculture, Transvaal, who stated that the product had been collected in Madagascar, and asking for information with regard to its commercial value and the name of the plant from which it was derived.

The specimen consisted of one capsule, about 6 inches long and $1\frac{3}{4}$ inches in diameter, which contained a number of seeds embedded in a mass of floss or silk-cotton. From the appearance and form of the capsule, and from a comparison of the seeds and fibre with those of known flosses or silk-cottons, there was little doubt that the product was derived from *Eriodendron anfractuosum*. The capsule yielded 22·4 per cent. of its weight of clean fibre, which possessed the usual properties of "kapok."

The material was extremely soft and silky to the touch, of good, even, deep-cream colour, of very good lustre and 0·6-1·1 inches long, a quantity of shorter fibres also being present. The diameter of the fibre measured $\frac{1}{2300}$—$\frac{1}{1000}$ inch, with an average of $\frac{1}{1300}$ inch. On microscopical examination the fibre was found to be fine, smooth, and regular.

The product was in every way equal, if not superior, to the standard sample of Java "kapok" used for comparison. It was stated that "kapok" of this quality would be of good commercial value, that exported from Java being worth 5*d.* to 6*d.* per lb. at that time in the London market.

The Argentine Republic.

Gomphocarpus brasiliensis.

A sample of a so-called silk-cotton, forwarded from the Argentine, together with a description of the plant from which it was derived, consisted of the seed hairs of *Gomphocarpus brasiliensis* (Fourn.), a plant of the Natural Order *Asclepiadaceæ*.

The material was brittle, of a very pale yellow colour, and composed of fine silky hairs varying from ½ inch to 1¼ inches in length. Like other products of this class it was not suitable for spinning, but could be used in upholstery for stuffing cushions, &c., and was worth about 4d. to 5d. per lb. in the London market.

PAPER-MAKING MATERIALS.

In the following pages reports are given of the investigation of a number of vegetable products with reference to their possible utilisation for paper-making. It is unlikely, however, that many of these products would be able to compete with the cheap materials at present employed, since the prices obtainable would not be sufficient to repay the cost of collection and transport.

East Africa Protectorate.

Adansonia digitata.

A sample of "Baobab" tree bark, from the East Africa Protectorate, consisted of strips of reddish-brown bark fibre, which were free from adherent woody matter, and varied in length from 3 to 5 feet.

On chemical examination it yielded the following results:—

	Per cent.
Moisture	9·7
Ash	6·2
Cellulose	60·8

The ultimate fibre measured 3·5-5·3 mm. (or 0·14-0·21 inch), and had an average length 4·5 mm. (or 0·18 inch).

The commercial experts to whom the sample was submitted stated that the material used to sell at about £5 or £6 per ton for paper-making, but that since the introduction of wood pulps it was probably not worth more than £3 per ton.

Further information regarding this fibre is given in the *Bulletin of the Imperial Institute*, 1904, **2**. 169, and 1907, **5**. 107.

Rhodesia.

Adansonia digitata.

A sample of "Baobab" tree bark, from Southern Rhodesia, was reported by commercial experts to be rough and coarse. It was stated, however, that the softer inner bark would probably be worth from £4 to £5 per ton.

Native Grass and Palm Leaf.

Samples of native grass and palm leaf, from North-Western Rhodesia, were sent for examination to the Imperial Institute by the British South Africa Company in 1907.

Grass.—This sample consisted of rather coarse dried grass, about 3 feet long.

A chemical examination of the material gave the following results:—

		Per cent.
Moisture	... ...	9
Cellulose	... ...	43 (calculated on dry material).

The length of the ultimate fibres varied from 0·3 to 0·9 mm., with an average of 0·5 mm.

The proportion of cellulose in the grass was too low to justify its use as a paper-making material. It might be used locally for tying or packing purposes, but it could not be profitably exported.

Palm Leaf.—The specimen consisted of flat, narrow, green leaflets, about 18 inches long, attached to a common petiole.

Chemical examination of the sample showed that it contained:—

		Per cent.
Moisture	.. ...	12
Cellulose	... ...	50 (calculated on dry material).

The length of the ultimate fibres varied from 0·5 to 1·3 mm., with an average of 1·0 mm.

The palm leaf thus contained a higher percentage of cellulose than the grass, and might be used locally for paper-making. It was considered improbable, however, that the material could be collected and exported profitably, as it would have to compete with the various cheap paper-making materials now in use, such as wood pulp and esparto grass. The value of esparto grass in this country is from £3 to £5 per ton according to quality.

TRANSVAAL.

Helichrysum species.

A small specimen, from the Transvaal, labelled *Helichrysum*, consisted of some nearly white, downy, fibrous leaves and a few bright yellow "everlasting" flowers.

In order to determine the possibility of using the leaves for the manufacture of paper, the percentage of cellulose in them was estimated. The following results were obtained:—

		Per cent.
Moisture	...	9·4
Cellulose	...	47·1 (calculated on the dried leaves).

The ultimate fibres had a length of 3·4-4·2 mm. (0·14-0·17 inch), with an average of 3·5 mm. (0·14 inch).

In the following table these results are compared with those furnished by a sample of Spanish esparto grass:—

	Helichrysum.	Spanish Esparto Grass.
	Per cent.	Per cent.
Moisture	9·4	13·2
Cellulose	47·1	54·8
Length of ultimate fibre	3·4-4·2 mm. (0·14-0·17 inch).	0·9-2·5 mm. (0·04-0·10 inch).

These results show that the leaves of *Helichrysum* would no doubt serve as a paper material, as they contain a large proportion of cellulose and an ultimate fibre of good length. The possibility of utilising the product in this way, however, would, of course, depend upon the cost of the material as compared with that of esparto grass or wood pulp, and upon the quality of the paper which it would yield. The latter point could only be ascertained by technical trials with large quantities of the material.

Cape of Good Hope.

Moræa tricuspis.

A sample of the fibre of *Moræa tricuspis*, Ker, was forwarded to the Imperial Institute by the Acting Agent-General for the Cape of Good Hope in 1907, for a report on the properties and value of the material.

The sample consisted of a greenish-grey coarse fibre, which appeared to have been partly separated from the leaves by crushing or scraping.

A chemical examination yielded the following results, for comparison with which the figures obtained for a specimen of Spanish "Esparto" grass have been added:—

—	*Moræa tricuspis.* Calculated on fibre as received.	*Moræa tricuspis.* Calculated on dry fibre.	Spanish "esparto" grass.
	Per cent.	Per cent.	Per cent.
Moisture	10·3	—	13·2
Ash	3·4	3·7	2·5 } On dry
Cellulose	53·5	60·0	54·8 } fibre.
Length of ultimate fibres...	0·4-1·6 mm., mean 0·7 mm.; or 0·016-0·064 inch, mean 0·028 inch.		0·9-2·5 mm., mean 1·7 mm.; or 0·04-0·10 inch, mean 0·07 inch.

It will be seen from these results that the sample of *Moræa tricuspis* fibre contained a higher percentage of cellulose in the dry material than the specimen of "Esparto" grass examined.

The individual *Moræa* fibres, separated from the material, were fine but of poor strength. They would be of no value for textile or rope-making purposes, the leaves being apparently too short to yield a fibre suitable for such applications.

The fibre could, no doubt, be utilised for paper-making, but would have to compete with cheap established products, such as wood pulp and "esparto" grass, and it seems unlikely that it could be profitably employed for this purpose. "Esparto" grass, which sells approximately at from £3 to £5 per ton, consists merely of the dried leaves, whereas the *Moræa* fibre submitted for examination had apparently undergone some rough process of treatment. Even if the dried leaves of *Moræa tricuspsis* were found to contain as much cellulose as "Esparto" grass, it is exceedingly improbable that it would pay to ship them to this country, though they might perhaps be used locally for paper-making.

"Palmiet" Plant.

The sample of Palmiet plant referred to in this report was forwarded for examination by the Trades Commissioner for the Cape of Good Hope in 1907.

The sample consisted of a very thick, woody stem with two bundles of long thin leaves, which were from 4 to 5 feet long and ¼ to ½ inch wide. Some of the leaves were removed from the stem and were chemically examined with the following results:—

		Per cent.
Moisture ...	...	9·4
Cellulose ...	...	43·0 (on the leaves as received).
		52·0 (on the dry leaves).

Length of ultimate fibres, 0·5-2·0 mm., average 1 mm.

The percentage of cellulose in the leaves was satisfactory, but the ultimate fibres were rather short. The leaves might be utilised locally for paper-making, but would probably not be of sufficient value to export for the purpose. In any case technical trials on a large quantity of the material would be required in order to ascertain its behaviour on a working scale.

Rushes.

A sample of rushes ("papkuli") was forwarded for examination by the Trades Commissioner for the Cape of Good Hope in 1907.

The rushes were exactly similar to English bulrushes in appearance, and were 7 feet in length. For chemical examination an average sample of the stem and leaves was selected, the flowering heads being rejected. The following results were obtained:—

		Per cent.
Moisture ...	...	48
Cellulose ...	...	27 (on the rushes as received).
		51 (on the dry material).

Length of ultimate fibres, 0·25-1·25 mm., average 0·75 mm.

In view of these results it is improbable that the rushes could be profitably utilised as a paper-making material. The percentage of cellulose is too low, the ultimate fibres are too short, and considerable difficulty would probably be experienced in getting the cellulose into workable condition.

West Africa.

Adansonia digitata.

The "Baobab" or "Monkey Bread" tree (*Adansonia digitata*) is extremely abundant in West Africa. The inner bark of this tree is very fibrous and is said to possess properties which render it of exceptional value for paper-making. In order to prepare the fibre, the hard outer bark is first removed by chopping, and the inner bark is then stripped off in large sheets. It is used by the natives for the manufacture of ropes and sacking. A short account of this material has been published in the *Bulletin of the Imperial Institute* (1904, **2**. 169).

An inquiry was received at the Imperial Institute in 1904 from a firm of merchants who desired information as to the possibility of obtaining this fibre, which was desired for a special purpose requiring a large and regular supply. Samples have been received at the Imperial Institute from Sierra Leone and from Lagos which are of the quality demanded, but apparently it is not possible to export the product in large quantities. It has been ascertained recently, however, that the fibre still reaches this country in small quantities and is being used in certain paper-mills.

Honckenya ficifolia.

A sample of the inner bark of *Honckenya ficifolia* ("Napunti"), forwarded from Sierra Leone in 1907, was examined from the point of view of its suitability for paper-making, and the results have been already recorded (page 42).

India.

Iris ensata var. *oxypetala.*

The following are the results of an examination of the leaves of *Iris ensata* var. *oxypetala*, a plant which is abundant in Kashmir. The sample was forwarded in 1906 with a request for information as to whether the product would yield a useful fibre, or whether it could be used for paper-making.

The sample consisted of green sword-like leaves measuring up to 3 feet in length and half an inch in width. The leaves contained only a moderate quantity of fibre, which was white and fine, but very weak. Attempts were made to extract the fibre by scraping and washing, but this was impossible owing to the weakness of the fibre.

On account of this lack of strength it is very doubtful whether the fibre would have any commercial value even if it could be successfully extracted.

In order to determine the suitability of the leaves for paper-making they were examined chemically and found to contain 42·3 per cent. of cellulose (calculated on the dry material). This is a much lower percentage of cellulose than is usually present in esparto grass, a sample of which, examined at the Imperial Institute, contained 54·8 per cent. of cellulose in the dry material. The ultimate fibres from the Iris leaves do not differ greatly in length from those of esparto grass, the fibres of which vary from 0·5 to 3·5 mm. in length with an average of 1·5 mm.

In view of these results it is improbable that these Iris leaves could be used as a source of fibre or that they could compete with such cheap paper-making materials as esparto grass or wood-pulp.

Musa textilis.

Samples of light brown sheaths of *Musa textilis* were forwarded from India in 1907.

The sheaths measured from 3 to 4 feet in length and 3 to 4 inches in width, and were tough and fibrous. On chemical examination they furnished the following results, for comparison with which the figures obtained for a specimen of Spanish esparto grass are also given:—

	Musa sheaths. Per cent.	Esparto grass. Per cent.
Moisture	16·3	13·2
Ash (on dry material) ...	18·7	2·5
Cellulose (on dry material) ...	30 to 35	54·8

It will be seen that the *Musa* sheaths contained a much lower percentage of cellulose and a higher percentage of ash than esparto grass.

An expert on paper-making, to whom a sample of the *Musa* sheaths was submitted, stated that it would not pay to import such material into this country for the manufacture of paper. He expressed the opinion that the low percentage of cellulose present and the cost of the chemical treatment necessary to remove the large amount of encrusting matter would render it impossible for paper-makers to pay more for these *Musa* sheaths than for esparto grass, the price of which is from £3 to £4 a ton.

The use which naturally suggested itself for these *Musa* sheaths is in the manufacture of Manila papers, which are at present prepared from Manila rope. The latter material can, however, be purchased at from £10 to £11 a ton, and yields with very mild chemical treatment about double the amount of pulp which the *Musa* sheaths would give. A further objection to the use of the *Musa* sheaths for this purpose would be that the paper mills which manufacture Manila paper are seldom, if ever, equipped with soda recovery plant, such as would be necessary for the recovery of the soda which would have to be used for treating the raw material.

It is possible that the dry sheaths could be utilised in the manufacture of the coarse matting used for packing machinery and furniture.

A question was raised by the expert as to whether the sheaths were really derived from *Musa textilis*, and definite information was asked for on this point. It was suggested that if there was any doubt about the botanical origin of the sheaths, specimens of the plant should be submitted to the Officiating Reporter on Economic Products to the Government of India at Calcutta or to the Economic Botanist at Bombay.

Spatholobus Roxburghii.

A sample of fibre of *Spatholobus Roxburghii* was forwarded to the Imperial Institute by the Reporter on Economic Products in 1899.

The sample was collected in Bengal. It was in a rough state, the bark and fibre not having been separated by retting. An attempt was made to isolate the fibre in the laboratory in order to obtain a specimen suitable for chemical examination, but this was unsuccessful since in the processes of retting and hackling the material broke up into small fragments which still retained non-fibrous tissue. It was, therefore, not thought worth while to submit it to chemical examination. Samples were, however, forwarded for commercial valuation, with the result that, in the condition in which it was sent, it was only considered suitable for paper-making and not worth more than about £3 per ton.

It was suggested that carefully prepared samples should be forwarded for examination if it was considered that the subject deserved further investigation.

Western Australia.

Xanthorrhœa Preissii.

A sample of the fibre of *Xanthorrhœa Preissii* was sent for examination to the Imperial Institute by the Agent-General for Western Australia in 1907.

Description of Sample.—One portion of the sample consisted of the interlaced fibrous woody tissue running longitudinally through the trunk, while another small piece, labelled, "Arrangement of fibres occurring in the plant," represented a section cut from the inner part of the stem, and was composed of interlaced fibrous tissue with stiff, radial fibres running through it, the interstices being filled with pithy matter. The fibrous tissue was very woody and of pale buff colour.

Value of the Fibre for Textile Purposes.—This fibre could not be used for any textile purpose as it lacks all the necessary characters which would render it suitable for utilisation in this way.

The deep-seated leaf bases, *i.e.*, the thick fibres occurring radially in the trunk, might perhaps be used in the manufacture of cheap brushes, such as scrubbing brushes, &c., but this would chiefly depend upon the possibility of extracting the fibre at a price to compete with the materials at present in use for this purpose.

Use of the Fibre for Paper-making.—The fibre was chemically examined with the following results. (The figures obtained by Mr. Mann, the Government Analyst, Western Australia, with another sample of the same material are given for comparison):—

	Per cent.		Results from Mr. Mann's Paper. Per cent.
Moisture	9·5	—	9·19
Ash	2·7	(on sample as received).	0·40
Cellulose	39·0	(on sample as received).	35·93 (crude fibre).

Length of ultimate fibres 0·4–5·5 mm., or 0·016–0·22 inch.

There was obviously a difference between the sample which was examined by Mr. Mann and that received at the Imperial Institute; the former contained only 35·9 per cent. of crude fibre, whilst the sample under examination contained a higher percentage of cellulose itself. The estimation of cellulose was rendered difficult by the tough woody nature of the fibre, which would probably also prove a difficulty in the manufacture of paper pulp, and would necessitate prolonged treatment with caustic soda or sulphite.

As the quantity of fibre available was small, a portion of the inner part of a trunk of the tree taken from the Imperial Institute Collections was used in the following experiments which were made to determine the suitability of the material for paper-making.

From the length and appearance of the ultimate fibres it was obvious that paper could be made from the fibrous core. An experiment was, therefore, made in order to obtain an approximate idea of the yield of "half-stuff" on boiling under pressure with caustic alkali for several hours as is done in the manufacture of paper pulp. Twenty-three per cent. of air-dry half-stuff (containing 9 per cent. of water) was obtained from the dry fibrous core, equivalent to about 15 per cent. of air-dry half-stuff on the raw inner core of the tree.

Paper could be made from the fibrous core, but experiments would have to be made on a technical scale to decide whether alkali or sulphite treatment would be more suitable, and also whether the manufacture would be remunerative.

A sample of very rough paper, prepared in the laboratory from some of the cellulose, was sent with the report.

TURKEY.

Broussonetia papyrifera.

Bark.—A sample of the bark of *Broussonetia papyrifera* was forwarded in 1905 to the Commercial Intelligence Branch of the Board of Trade by His Majesty's Vice-Consul at Broussa, Turkey, and was transmitted to the Imperial Institute, with a

letter from the Vice-Consul stating that the product was available in large quantities, and asking for an opinion as to its commercial use and value.

The sample consisted of two small bundles of fibrous ribbons, which were very stiff, yellowish in colour, from 3 to 5 feet long, and had evidently been submitted to a chemical bleaching process.

On chemical analysis, the product furnished the following results:—

	Per cent.
Moisture	10·2
Ash	4·4
Cellulose	59·0

When boiled for five or ten minutes with a dilute solution of caustic soda the material readily separated into its ultimate fibres. There is no doubt, therefore, that the bark was very suitable for paper-making, since it contained so large a proportion of cellulose and broke up so readily into long ultimate fibres.

A specimen of the fibre, extracted from the ribbons by the action of caustic soda and afterwards thoroughly washed with water, was of white and lustrous appearance. The fibres were of somewhat poor strength, had an average diameter of 0·0006 inch, and were 0·7 to 1·1 inches long, many shorter fibres also being present. On microscopical examination, the fibre was found to be fine and regular, and to possess transverse markings not unlike those of flax fibre; in some cases, however, these markings were but faintly developed and the fibre, therefore, presented a smoother surface.

The commercial experts reported that consignments of this material, of rather rougher quality than the present sample, used at one time to come into the London market from the East and realised £20 per ton, but that since the introduction of wood pulp the demand for this product had ceased.

The results of the examination of this sample of *Broussonetia* bark have shown that its fibre is fine and lustrous and well suited for paper-making. The product has never been used on a very large scale in Europe as a paper-making material, although it has been employed occasionally by certain manufacturers for the preparation of special papers. At the time of this report, however, there appeared to be no opening for *Broussonetia* bark in this country.

Fibre.—A sample of fibre, from the bark of *Broussonetia papyrifera*, was forwarded for examination to the Imperial Institute by the British Vice-Consul at Broussa, Turkey, in 1905. It was stated that the material was prepared by a chemical process, and was considered locally to be superior to wood pulp for paper-making, and to be also suitable for spinning into yarn.

Description of Sample.—The sample consisted of clean, prepared fibre, varying in colour from pale-cream to white. The

fibres adhered firmly together in tufts, and could only be separated from one another with difficulty. The material was of poor lustre and harsh to the touch.

The fibres were of fairly good strength, but brittle and inelastic. The length of the individual fibres varied between 0·8 and 1·6 inch, the average length being 1 inch, whilst their average diameter was 0·0006 inch, with a variation between 0·0003 and 0·0009 inch. The fibre was thus rather finer than ordinary cotton.

Results of Examination.—The chemical examination of the fibre gave the following results:—

	Per cent.
Moisture	7·3
Ash (calculated on dry material)	2·9
Cellulose (calculated on dry material)	83·2

The percentage of cellulose was fairly high, but the fibre was inferior in this respect to cotton, which usually contains 95 to 97 per cent. of cellulose.

Carding tests were made in order to determine the possibility of working the material, but prolonged treatment only partially separated the fibres, whilst their length was seriously reduced in the operation.

Treatment with dilute alkali also failed to effect the separation of the fibres.

Conclusions.—It was almost impossible to separate this material into single fibres, as would be necessary before it could be spun. Very drastic treatment in carding might effect a complete separation, but owing to the fineness of the fibres they would be much broken up and reduced in length during the operation.

The material could no doubt be used for paper-making if it could be produced at a sufficiently low price to enable it to compete with the materials at present in use. For this purpose, however, it would be quite unnecessary to isolate the fibre as the bark could be used in an unprepared state.

The fibre could doubtless be used as a source of cellulose for the manufacture of artificial silk, but in this case also it would have to compete with such cheap materials as cotton waste and wood pulp.

OTHER FIBRES.

SUDAN.

Leptadenia species.

In 1904 a consignment of "Marakh" (*Leptadenia* sp.) twigs was forwarded to the Imperial Institute from the Sudan, with a letter stating that attempts had been made locally to extract the fibre from this material but without success. Experiments were

carried out in the Scientific and Technical Department of the Imperial Institute with the object of isolating the fibre, but the results showed that it was not possible to extract it satisfactorily from the dry material. In a preliminary report, which was forwarded to the Agent-General, Sudan Government, it was recommended that further attempts should be made in the Sudan to prepare the fibre from the fresh twigs, and processes were suggested for this purpose which it was thought might perhaps yield the desired result.

Further samples, consisting of some extracted fibre and a specimen of rope made from it, were forwarded in 1905. It was stated that the fibre had been retted and the rope prepared at the Government Experimental Farm, Khartum, and that as the result was unsatisfactory another trial would be made.

The specimen of fibre consisted of very short tangled fibres mixed with a considerable quantity of green tissue. The material could easily be separated into the ultimate fibres.

The sample of rope was roughly made, stiff and easily frayed, but seemed of fair strength.

On chemical examination, the fibre yielded the following results:—

	Per cent.
Moisture	7
Ash	6·5
Cellulose	73

By carefully combing the material, a clean fairly soft specimen, consisting of the ultimate fibres, was obtained, which was fine and of irregular length, varying from 0·5 to 1·8 inches. Microscopical examination showed that the surface of the fibre was smooth, and that the diameter was about $\frac{1}{1500}$ inch. The fibre was of good strength, stronger than a cotton of equal diameter, but was inelastic and brittle. Owing to the shortness of the fibre and the absence of any spiral or scale structure on its surface, the material would not spin satisfactorily alone, except to produce a coarse tightly twisted yarn or rope strand. If very carefully cleaned, it might possibly be spun in admixture with flax or other similar material, but it was not considered probable that its use in this way would be remunerative even if it should prove to be practicable.

From the results of the examination it was evident that "Marakh" fibre would be of little or no value in the condition of this sample. If, however, the material could be obtained in long strands or filaments, well cleaned and prepared, it would probably be of value for textile purposes.

East Africa Protectorate.

Raphia species.

A sample of *Raphia* ribbons, produced at Taveta, were of light-brown colour, well cleaned, and of good strength. The length of staple varied from 4 feet to 5 feet 6 inches. A portion

of the sample was submitted to commercial experts for valuation. They reported that it was similar to the "fair ordinary quality" of *Raphia* fibre as now imported, and that it would be worth from £28 10*s*. to £29 per ton, but that if it could be obtained of lighter colour it would probably be worth from £1 to £1 10*s*. per ton more.

NYASALAND.

Pouzolzia hypoleuca.

A sample of "Lichopwa" fibre (*Pouzolzia hypoleuca*), forwarded to the Imperial Institute, consisted of brown ribbons of fibrous material, which contained much gummy matter. The fibre when freed from the gummy substances was soft but weak.

The following are the results of its chemical examination:—

	Per cent.
Moisture	11·8
Ash	9·8
α-Hydrolysis (loss)	43·4
β-Hydrolysis (loss)	51·0
Nitration (gain)	8·9
Cellulose	38·5
Length of ultimate fibre	3·7-15·2 mm. or 0·15-0·6 in. (mean 8·6 mm. or 0·35 in.).

The fibre was not lignified. The figures given above show that the sample contained a very large percentage of matter other than true fibre; the percentage of ash is high, and the losses on hydrolysis, which would be quite abnormal in a cleaned fibre, can only be accounted for by the presence of a large amount of pectous or gummy matter. Commercial experts to whom this sample was submitted reported that fibre of such quality would only be saleable at a nominal price.

TRANSVAAL.

Samples, consisting of a small bulb and a specimen of the fibre of a species of *Hypoxis*, were received from the Transvaal.

The bulb was of a dark-brown colour, and bore a tuft of dead leaves, and some short, harsh, bristly fibre in a circle at the base of the leaves.

The specimen of fibre consisted of dark-brown, smooth, stiff and wiry, somewhat lustrous, curly fibres, which varied in length up to 4 or 5 inches. The product was resilient, fairly strong but slightly brittle. The fibres were elliptical in section, the longer diameter measuring $\frac{1}{40}$ to $\frac{1}{50}$ inch, whilst the shorter measured $\frac{1}{120}$ to $\frac{1}{150}$ inch.

The fibre resembled horsehair, but was too short to be utilised as a substitute for this material in the manufacture of hair fabrics. The product could be used, however, either alone or

mixed with hair as a stuffing material in upholstery, although it does not appear likely that its collection and employment for this purpose would prove remunerative.

Vellozia retinervis.

A sample, forwarded from the Western Transvaal, consisted of a portion of the stem of a plant, was about 14 inches long, and bore a few dry grass-like leaves at the upper end. For about 9 inches of its length, the stem was covered with hard, thin, shiny, dark-brown scales, beneath which were a number of light-brown ærial rootlets attached to a small central-woody cylinder. The lower part of the specimen consisted of rootlets only.

The coarse rootlets were easily detached from the stem; they varied in length up to 12 inches, were of a light-brown colour, and were covered with a soft pithy sheath or velamen which, on removal, revealed a group of from 4 to 10 fibres of the same length as the rootlet itself. The diameter of the rootlets was from $\frac{1}{36}$ to $\frac{1}{16}$ inch, whilst that of the fibres was from $\frac{1}{125}$ to $\frac{1}{50}$ inch. The fibres were yellowish brown, slightly wavy, dull and opaque; in some cases they were of fairly good strength, but the greater number were weak and brittle.

With regard to the utilisation of the product, although it might be of some service locally, for rough purposes, yet it would not be able to compete successfully in England with the much superior materials usually employed for cordage. Even if the fibre could be obtained of much greater length, it would be unsuitable for the manufacture of rope on account of its deficiency in strength and of the difficulty of freeing the fibres from the sheath by which they are surrounded, an operation which would add considerably to the cost of preparation.

Experiments showed that the material was quite unsuitable for the manufacture of paper pulp; the fibre was extremely hard, and did not break up except under very severe treatment.

The plant was identified at Kew as *Vellozia retinervis*, Baker, of the Natural Order *Amaryllideæ*.

India.

Nannorhops Ritchieana.

A sample of fibre, obtained from the leaves of a dwarf palm, *Nannorhops Ritchieana*, known as "Mazari," which grows abundantly in the Kuram Valley, Baluchistan, and Sind, has been examined. The fibre is said to be largely employed in India for the manufacture of rope, whilst the leaves are made into baskets, mats, fans, and other articles.

The sample consisted of pale greenish-brown fibre, which was rather coarse, non-lustrous, harsh to the touch, not very well cleaned, and about 2 feet 3 inches long.

The strength of the material was somewhat inferior to that of Sisal hemp and similar fibres of average quality.

On chemical examination the fibre yielded the results which are given in the following table. The corresponding figures, furnished by a sample of a somewhat similar fibre from Victoria, derived from the leaves of *Dracæna Draco*, are added for comparison:—

	Nannorhops Ritchieana from India. Per cent.	*Dracæna Draco* from Victoria. Per cent.
Moisture	10·3	11·2
Ash	2·0	1·7
α-Hydrolysis (loss) ...	14·2	18·6
β-Hydrolysis (loss) ...	20·7	22·1
Acid purification (loss) ..	3·8	10·0
Cellulose	65·2	69·2
Length of the ultimate fibre	1·1-2·5 mm. (0·04-0·1 inch).	1·5-2·5 mm. (0·06-0·1 inch).

These results show that the *Nannorhops* fibre resembles that of *Dracæna* in general chemical behaviour and composition, but contains a somewhat lower proportion of cellulose. The product is evidently not a fibre of very high quality, since, like the *Dracæna* fibre, it suffers considerable loss when boiled with dilute alkali (α- and β-hydrolysis), and is particularly poor in cellulose. It must be remarked, however, that the fibre would probably yield rather more satisfactory results if it were more carefully prepared.

Commercial experts, to whom the sample was submitted, reported that the product was a dry, harsh fibre, of poor, dull colour, of doubtful spinning quality, fairly strong but brittle, and probably worth from £12 to £15 per ton in the London market.

It is evident, therefore, that the fibre of *Nannorhops Ritchieana* is not of very promising quality, although perhaps more carefully prepared specimens would exhibit somewhat better characters than those of the present sample.

Although the fibre is doubtless very serviceable to the natives, it appears to possess no distinctive property which would render it of value for any special purpose, and, consequently, it is not very likely that it would be able to compete successfully with the many superior fibres produced in India.

Tacca pinnatifida.

The attention of the Imperial Institute was first directed to the utilisation of the fibre of *Tacca pinnatifida* as a braiding material by a firm of fibre brokers, who asked to be supplied with samples of this product from India. This request was transmitted to the Reporter on Economic Products in 1898, and, in response, samples were forwarded to the Imperial Institute in 1902. These samples were submitted to fibre experts and dealers, who reported that unfortunately they were quite different from the carefully prepared *Tacca* usually met with in the market, and were, consequently, of no value.

Two further samples of *Tacca* fibre were forwarded in 1904, which had been prepared by merely scraping the green stems of plants grown in the Royal Botanic Gardens, Sibpur.

One specimen consisted of ribbons prepared from the young stalks, whilst the other was obtained from mature stems. Both specimens were submitted to the commercial experts referred to above, with a request that they would report on the suitability of the products for braiding purposes, and also state whether there was any demand for such material at that time.

It was reported that the sample derived from the immature stem was of the quality usually met with in the London market, and that sales of such material had been made recently at 5*s.* per pound. It was stated that the specimen obtained from the mature stem was of coarser grain than the ordinary commercial samples, but that there was a possibility that some manufacturers might consider this an advantage. The ribbons should not be less than 10 to 12 inches long. It was also stated that the trade in this fibre could not be regarded as likely to be permanent, although the demand for the material had been maintained at intervals and would probably be continued during the next season. The product is only used in limited quantity, and any large increase in the supply would cause a considerable fall in prices.

SOUTH AUSTRALIA.

Posidonia australis.

The attention of the Imperial Institute has on several occasions been directed to a fibrous substance which is found on the foreshore of Spencer's Gulf, South Australia, under a deposit of sand varying from 6 to 8 inches in depth.

This material consists of short, harsh fibre, somewhat resembling jute, and has a quantity of broken shells associated with it. The product is reddish-brown, of poor lustre and very uneven strength. Some of the long fibres are fairly strong, but the greater part are weak and brittle. The length of the fibrous strands varies from about 1 to 5 inches. The ultimate fibres are very short (about 0·03 to 0·05 inch) and from 0·0008 to 0·003 inch in diameter.

A specimen, which was submitted to chemical examination, furnished results which are compared below with those given by a sample of Indian jute. Before analysis the fibre was freed as far as possible from sand and fragments of shells.

	The South Australian fibre. Per cent.	Indian jute, extra fine quality. Per cent.
Moisture	11·8	9·6
Ash	6·1	0·7
α-Hydrolysis (loss)	0·4	9·1
β-Hydrolysis (loss)	1·9	13·1
Acid purification (loss) ...	7·8	2·0
Nitration (gain)	7·0	36·7
Cellulose	55·9	77·7

The behaviour of the fibre with reagents showed that it is highly lignified. The percentage of cellulose is lower than that of most fibres of non-marine origin. The high percentage of ash is due to the particles of shells or sand which still adhere to the material, and the exceptionally small loss on hydrolysis is probably explained by the fact that the fibre has undergone prolonged exposure to the action of sea-water.

A series of experiments was made in order to determine the behaviour of the fibre when submitted to certain technical processes, such as carding, bleaching and dyeing. When carded, the material furnished an excessive amount of short fibre, and on prolonged treatment the greater part became broken up. The fibre was found to be very difficult to bleach, but in the dyeing experiments it was found to behave very similarly to jute.

The fibre could be spun, either alone or mixed with jute, into a coarse yarn suitable for the manufacture of carpets and similar fabrics. There would, however, be excessive waste in the processes of manufacture and the finished products would be of inferior strength.

The fibre could be used as a paper-making material, although for this purpose the percentage of cellulose is low, and it would be necessary to remove the associated mineral matter. It is probable, however, that it would meet with a ready sale as a paper-making material if it could be placed on the market at a price which would enable it to compete with other materials of this class.

The following interesting notes on this fibre are taken from the *Proceedings of the Linnean Society of New South Wales.*

"Mr. R. T. Baker exhibited a sample of vegetable fibre, which appeared like teased-out coconut fibre. This material is found at Tickera, fifteen miles north of Wallaroo, South Australia, and runs in a straight line from the beach inland in a generally easterly direction for some distance. At the beach it is 15 feet wide, and at the eastern end it tapers out to a mere trace. The origin of this remarkable deposit is so far unknown, and a microscopical investigation determined it to be a vegetable, consisting of cellulose and lignin. Locally it is known as 'kelp,' but that is incorrect, as seaweeds do not contain vascular bundles" (*Proc. Linn. Soc. N. S. W.*, May 30, 1906).

"Mr. A. G. Hamilton exhibited a ball of vegetable fibre similar to that exhibited at the last meeting by Mr. R. T. Baker. It was picked up on a beach near Albany, Western Australia, where there was an area of three or four acres covered with balls and cylinders rolled by the action of the waves. The bay was shallow and the bottom covered with a thick growth of some grass-leaved plant like *Zostera*, and it was from the decayed leaves that the fibre was derived. As there were no flowers or fruit it was impossible to determine the plant" (*Proc. Linn. Soc. N. S. W.*, June 27, 1906).

"With reference to the fibre exhibited by Mr. R. T. Baker at the May meeting, and commented upon by Mr. A. G. Hamilton

at the June meeting, Mr. Maiden expressed the opinion that it was probably the product of a marine plant, *Posidonia australis*, Hook. f. (*Naiadeæ*). 'The bases of the stems covered with the filamentous remains of old leaf-sheaths' is a character of the genus, those of *P. australis* being covered with longer and finer filaments than in *P. oceanica*, the European species. Mr. Maiden exhibited specimens of *P. australis* showing the fibre *in situ*, and he drew attention to the possible importance the finding of the *Posidonia* fibre may have from a geological point of view.

"*Posidonia* grows at the present day on the coasts of Tasmania and Southern Australia as far as New South Wales. The fibres are firmly attached to the plant, and it is, therefore, very unlikely that the fibres could have been washed on shore where they were found. The finding of the fibre appears to indicate not only that there has formerly been an ocean bed, but also that the depth of the water could not have exceeded the maximum depth in which *Posidonia* is found growing now" (*Proc. Linn. Soc. N. S. W.*, July 25, 1906).

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Botanical names are printed in italics.

COLONIAL REPORTS—MISCELLANEOUS.

No. 63.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT.

Edited by the DIRECTOR.

II.—GUMS AND RESINS.

(For Part I., Fibres, *see* No. 58, Cd. 4588 of 1909.)

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No. 63.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

II.—GUMS AND RESINS.

INTRODUCTION.

The first of this series of "Selected Reports from the Scientific and Technical Department of the Imperial Institute" dealt with the subject of fibres [Cd. 4588, 1909]. The present publication, the second of the series, deals with gums and resins, two important groups of commercial products the technical value of which can now be determined by scientific methods. The most important gums are those of the "gum arabic" class, which are imported to this country almost entirely from the Sudan and the French territory of Senegal. At present the world's demand appears to be sufficiently met from these two sources. The examination at the Imperial Institute of gum from Northern Nigeria has shown that this material, which is very abundant in certain districts in the Protectorate is also suited to the requirements of the British manufacturer, and enquiries are now in progress to ascertain whether the present small trade in Northern Nigeria gum can be extended, especially in view of the transport facilities which will be forthcoming when the Northern Nigerian Railway is completed. The gum would be shipped from a Southern Nigerian port to Liverpool.

At one time there was a considerable trade in this gum, which reached Europe by caravan across the Sahara to Tripoli, whence it was shipped to Trieste. In recent years this caravan trade has sunk to very small dimensions. Owing to this and other causes Trieste is no longer the centre of a great gum-sorting industry.

In connection with resins, the work conducted at the Imperial Institute on the copals of West Africa points to the conclusion that this material is abundant, and that the present small trade if properly organised is susceptible of considerable enlargement.

The investigations of gums and resins at the Imperial Institute have been made under the superintendence of Dr. T. A. Henry, assisted by several other members of the staff of the Scientific and Technical Department, whilst several firms of merchants and manufacturers have kindly given their services as referees on these subjects.

WYNDHAM R. DUNSTAN.

October, 1909.

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GUMS.

The term "gum" is used commercially to designate a great variety of natural products, including such diverse materials as the true gums derived from acacia and tragacanth trees, resinous products such as benzoin and copal, drugs such as kino and opium, and miscellaneous substances like camphor, gutta-percha and rubber. The name should, however, be reserved for products such as gum arabic and gum tragacanth, which are miscible in all proportions with water to form viscous liquids known technically as "mucilage."

Gums are used for a great variety of purposes in the arts, and the trade in gums is of considerable dimensions and of great importance in several British Colonies and Dependencies.

The true gums are divisible into three classes—(a) *soluble gums*, typified by those produced in the Anglo-Egyptian Sudan and in Senegal, which dissolve in water, forming transparent viscous, adhesive solutions; (b) *insoluble gums*, represented by tragacanth gum, which, when placed in water, absorbs the latter and swells into a jelly, and finally, on addition of sufficient water, breaks down into a very thick translucent solution; (c) *semi-insoluble gums*, such as "Persian insoluble gum," which is intermediate in properties. It partially dissolves in water, leaving a swollen jelly, which on the addition of more water also passes into solution.

These three classes of true gums may be readily distinguished from the resins, balsams, and drugs to which the term "gum" is often wrongly applied in commerce, by the fact that they are miscible with water in all proportions and are insoluble in liquids such as alcohol, oil of turpentine, benzene, or fatty oils (*see also* p. 177).

Uses of Gums.

Soluble gums are applied to a great number of purposes in the arts. The finest and least-coloured varieties are employed in the clearing of liqueurs, the "finishing" of silk, and in the preparation of fine water colours. The other high-class grades find application in confectionery and pharmacy, in the "finishing" of textiles and paper, in calico-printing, and certain dyeing processes. The less costly varieties are used in the manufacture of stationery, matches, and inks.

The value of a gum for use in confectionery depends principally upon its freedom from colour, odour, and taste, and its "strength" as measured by its viscosity. For pharmaceutical use a fairly high viscosity, considerable adhesive power and freedom from colour are the principal requirements; for the preparation of mucilage to be used in the manufacture of stationery, adhesive power is the principal factor taken into account, though for certain special work the absence of a dark colour is advantageous.

The commercial value of a gum, therefore, depends largely on the purposes for which it is suited, the highest price being

obtained for gums suitable for "finishing" silk and for the use of confectioners and pharmacists, and the lowest for those which can only be employed for the preparation of ink, &c.

As regards the "insoluble" gums, tragacanth is in frequent use as one of the thickening agents necessary in preparing the mixtures of colours used in calico-printing. In this industry coloured pastes of suitable consistence are printed on the fabrics, and it is most important that the colours should not run, but should produce patterns with sharply defined edges. Great skill and experience are required in preparing such pastes. It is stated that in giving consistence to a liquid, with equal parts of water, 10 parts of gum tragacanth are equivalent to 20 parts of starch, or 22 parts of wheat flour, or 130 to 140 parts of "calcined" starch. It is important that the gum used should not affect the brightness of delicate colours, nor weaken the mordants by its acidity or in other ways; it is also desirable that the thickening agent should not penetrate too far into the fabric. In printing dark colours, the smaller the quantity of thickening agent that will give the necessary consistence, the less the colour is lightened by dilution

Tragacanth is also used in pharmacy for keeping heavy powders in suspension in liquid preparations, and sometimes as an absorbent for liquids.

Chemistry of Gums.

The present position of our knowledge of the chemistry of gums formed the subject of a report prepared for the York meeting of the British Association for the Advancement of Science in 1906 by Mr. H. H. Robinson, of the Scientific and Technical Department of the Imperial Institute, and from this report the following summary is made.

The gums are uncrystallisable substances composed of carbon, hydrogen, and oxygen. As found in nature they contain more or less ash constituents, and sometimes a little nitrogen. The nitrogen, if present, is small in amount, and is not regarded as an essential component, and this differentiates them from gelatin, glues, and proteins, which resemble gums in their physical properties, but contain a considerable proportion of nitrogen.

Different views have been held as to the processes by which gum is formed in plants. One view considers the production of gum as part of the normal processes in plants; in the case of tree gums they are generally regarded as excretions resulting from the breaking down of cell tissue. In certain cases the formation has been attributed to the action of a fungus, which attacks the tree and generates an enzyme (unorganised ferment) that penetrates the tissues and transforms the cell walls, &c., into gum. A third view attributes it to bacterial action, and it is claimed that specific bacteria have been found capable of producing different kinds of gum. The employment of a system of inoculating the trees to cause the production of gum has been suggested, but the evidence in support of it is as yet very slight.

The views held regarding the chemistry of the gums have passed through various stages. The work done in the early part of the nineteenth century resulted in the description of the properties of a few gum substances believed to be individual chemical compounds, to which the names *bassorin*, *cerasin*, and *arabin* were given. *Bassorin* was the substance constituting "gum Bassora," a gum having properties somewhat similar to those of tragacanth, but not so highly valued. It derived its name from the Turkish port now called Basra, at the head of the Persian Gulf, from which there is a considerable export of gum. *Cerasin* was the gum substance obtained from the fruit of the plum known as "Mirabel," and also from the stem of the wild cherry tree (*Prunus avium*). The gum of the sweet cherry tree is of a different nature. *Arabin* was the gum substance of gum arabic and of Senegal gum, and *para-arabin* was the name proposed for an insoluble form of the same substance. After these names had been assigned, chemists, dominated by the idea that the number of organic compounds was only small, on investigating a gum, identified its constituents with one or more of these substances. As these identifications rest on a few simple properties, but little weight attaches to them. In fact, it appears now that the number of gum compounds is very considerable; consequently, in reading the literature of the last century, statements that the author had found arabin, or cerasin, or bassorin, &c., do not throw any certain light on the nature of the substance found, as it cannot be safely inferred that it is the same substance as the arabin, or cerasin, or bassorin, &c., found in another natural product by another author.

In the middle of the century it was discovered that gum arabic is composed of an acid to which the name "arabinic acid" or "arabic acid" was given; in the natural gum this acid is united to bases (calcium, magnesium, &c.) forming salts. Until nearly the end of the century the gums were believed to be carbohydrates, that is, substances like sugar, starch, and cellulose, which are composed of carbon united to hydrogen and oxygen, present in the same proportions as in water, and the formula $C_{12}H_{22}O_{11}$ or $(C_6H_{10}O_5)n$ was assigned to them. Towards the end of the century, however, it was shown that the gum substances are not carbohydrates, but complex acids built up of a nucleus acid with which are combined several of the less common sugars, such as galactose, arabinose, and xylose. The natural gums are mixtures of the potassium, calcium, and magnesium salts of one or more of these complex acids. Among the nucleus acids are arabic acid in gum arabic, geddic acid in "Gedda gum," and bassoric acid in gum tragacanth. The name "arabic acid" is here used for the nucleus acid and not for the complex natural acid, for which the term "arabinic acid" is more suitable.

The proportions of the sugars united to the nucleus acid to form the natural complex gum acid, and the proportions of the complex acids in the mixture that constitutes the natural gum, appear to vary in different seasons, since investigations have shown that the properties of the gum of a given plant are not always the same.

ANALYSIS AND VALUATION OF GUMS.

Closely allied to the subject of the chemistry of gums are those of their analysis and valuation for industrial purposes. The analysis of a gum may be undertaken with one of two objects in view—(1) the detection of sophistication, or (2) the determination of its value in comparison with standard classes of commercial gum. At one time, when gum of good quality was scarce and dear, the first object was frequently of some importance, but at present gum of fine quality is so cheap that adulteration is scarcely remunerative, and the object of analysis is usually to ascertain how a sample compares with standard materials.

One of the most important factors in determining the quality of a gum is the viscosity (or roughly "thickness") of the solution it forms with water, and as no standard method is yet in use by analysts for observing this constant in the case of gums, the results recorded by different investigators are not comparable, and this difficulty renders it necessary to refer in some detail to this matter here.

The simplest method of determining the viscosity of a solution is to allow a quantity to flow out of a tube, provided with a capillary orifice, under its own weight and to note the "time of flow." In this method the pressure under which the liquid flows varies continuously, and there are other disturbing factors which render the results so obtained of little value, though the method is still in use as affording a rough comparison of the viscosity of a solution of one gum with that of another.

A second method, which is an improvement on the foregoing, is to note the time taken by a definite volume of the liquid to flow out of a tube, provided with a capillary orifice, under a constant pressure due to a column of the same liquid maintained of the same length throughout the operation by a regulated inflow from an external supply.

Lastly, recourse may be had to the use of a viscosimeter consisting of a capillary tube, enlarged at one part of its length into a cylindrical bulb, along a definite length of which, including the bulb, a measured volume of the liquid is caused to flow under a constant pressure and the time in seconds required for this is noted. This last apparatus was used in the determination of most of the viscosities recorded in these reports, and is a little simpler than Ostwald's viscosimeter (*Physico-chemical Measurements*, 1st edition, p. 163), generally employed in investigations on viscosity. Dr. Beam, of the Gordon College at Khartoum, has suggested recently the use of Doolittle's viscosimeter for the determination of the viscosities of gum solutions. The working of this instrument is based on the fact that the resistance offered by a liquid to the rotation in it of a metallic disc is dependent on the viscosity of the liquid. This method of measuring vicosity has been used largely in the United States for determining this constant in the case of lubricating oils, but has been little applied elsewhere, and as all the methods in general use for gums depend on the flow of liquids out of or

through glass tubes, it seems desirable to develop a more accurate method on these lines rather than to apply an instrument depending on a different principle. It is, perhaps, also worth mentioning in this connection that the determination of the viscosities of pure organic substances, solutions of salts in water, &c., has been the subject of much investigation in recent years, and in most of this work viscosimeters of the Ostwald type have been employed on account of their greater accuracy; and although in the analysis of a gum for commercial purposes the refinements which are necessary in the pursuit of a purely scientific investigation need not be introduced, the fact that more accurate results are obtainable by the use of a capillary tube viscosimeter affords an additional reason for adhering to such a method.

It will be evident from what has been said above that the viscosity of its solutions in water is an important factor in arriving at an indication of the value of a gum. It is desirable that a uniform method of determining this constant should be adopted, since this seems to form one of the readiest means for a systematic examination of the quality and nature of gum produced under different conditions, matters which it is particularly desirable should be studied with a view to the improvement of gum productions in such countries as the Anglo-Egyptian Sudan and Northern Nigeria. With this end in view an Ostwald's viscosimeter of suitable size for the examination of gum solutions has been used recently at the Imperial Institute, since this instrument is inexpensive, is readily obtainable from apparatus dealers, gives accurate comparative results, and is in common use in laboratories for viscosity determinations.

In addition to the viscosity determination, it is generally necessary to ascertain the percentage of moisture present in a sample of gum, the amount of ash it contains, its acidity, and the colour, taste, odour, and character of the solution it forms with water. The amount of moisture present should be merely enough to prevent the gum being excessively friable, and as a rule it varies between 12 and 16 per cent. The ash should be merely that due to the bases combined with the natural gum acid, and in good samples is generally about 3 per cent. The solution should be free from marked taste or odour and not very dark in colour. For use in medicine the solution of gum should in addition conform with the requirements of the British Pharmacopeia, which are designed to exclude from medicinal use gum substitutes and gums inferior to the gum arabic of the Anglo-Egyptian Sudan and Senegal.

GUMS EXAMINED AT THE IMPERIAL INSTITUTE.

In the volume of "Technical Reports and Scientific Papers," published by the Imperial Institute in 1903, a number of gums from India were dealt with (Part I., page 158). These included gums from *Bauhinia retusa*, *Odina wodier*, *Buchanania latifolia* and *Prunus eburnea*. Of these the second and the fourth were regarded as likely to be of commercial value and readily saleable if obtainable in considerable quantities.

Since that date a very large number of samples of gums hav been received for examination from British Colonies and Depen dencies, and in addition several memoranda have been pre pared for the information of the authorities in such Colonies an Dependencies on various aspects of gum production. In con nection with this work it has been necessary to examine fo purposes of comparison a number of samples of gums fron foreign countries, and consequently the matter available fo publication on gums in the present series of collected reports covers a wide range of products from practically all the pro- ducing countries. It is convenient therefore to arrange it unde the heads of the three types of gum already referred to, viz., "soluble," "insoluble," and "semi-insoluble" gums, and t sub-divide the samples falling under these heads, according t their countries of origin. For the sake of completeness shor notes on the production of gum in a few countries from which n samples have been received are added. The most important o these are Morocco, Somaliland, Abyssinia, Persia, and Asi Minor.

These investigations have been carried out on the lines indi cated above. In addition, in those cases in which the results o analysis indicated that the gums were likely to be of saleabl quality, samples were submitted to brokers and to manufacturer for valuation and technical trial.

SOLUBLE GUMS.

Anglo-Egyptian Sudan.

The gum produced in the Sudan has been an article of com merce since the first century of the Christian era, when it wa shipped from Egypt to Arabian ports and thence sent to Europe; hence the designation "gum arabic," still frequently applie to gums of this type. In the Middle Ages the trade was carried o through Turkish ports, hence the name "Turkey gum" still i use, though the trade from Turkish ports has long since ceased At present the gum is generally known as "Sudan" or "Kordo fan" gum.

In the Sudan the best gum is collected from the grey-barke acacia tree, *Acacia Senegal*, known locally as "hashab." Inferio varieties are obtained from the "red" and "white" barke acacias, both of which are varieties of *Acacia Seyal*, and ar known locally as "talh" or "talha." A certain amount o gum is collected in the Blue Nile district, and there is a fai gum trade at Gedarif, which lies between the Blue Nile an Abyssinia; but the quality of the "hashab" gum produced ther is hardly equal to that of the province of Kordofan, which is th principal seat of the gum-collecting industry. Kordofan lies t the west of the White Nile, some 200 miles south-west of Kha

toum. In this province the gum is transported either direct to Khartoum by camels or to Goz Abu Guma and El Dueim, towns on the White Nile, and is there put into boats.

The greater part of the gum was formerly dried and cleaned at Omdurman, which lies on the Nile opposite Khartoum; but at present only about 8 per cent. is treated there, and the rest is sent direct to Cairo and Suez or Port Said, where it is exported to Europe, &c. At least one-half goes to Suez. The gum loses about 15 per cent. by evaporation between the garden where it is gathered and the port of export. There is also an export of gum from Suakim, and it is probable that with the completion of the Berber-Port Sudan Railway, a much larger proportion of the gum exports will pas *via* this route to the Red Sea and the Mediterranean.

In Kordofan the gum is obtained both from gardens of acacia trees, which are private property, and from wild or unowned trees; the first kind is known as "hashab geneina" (*i.e.*, garden hashab), and the second, which is of less value, is known as "hashab wady." The latter exudes naturally from the trees, and is slightly darker in colour; it is usually in pear-shaped pieces of variable size proportionate to the length of time between successive collections. A dirty gum which is sometimes found exuding is known as "kadab," and is rejected.

The conditions favourable to the production of gum are a ferruginous sandy soil, with a good natural drainage, and probably a moderately heavy rainfall during the rainy season is beneficial, and dry heat during the collecting season. Excessive moisture in soil otherwise suitable appears to prevent the production of gum.

In the "geneinas" gum is obtained by artificially incising the trees. Soon after the end of the rains, bark is removed in strips from the principal branches of all trees in the garden of 3 years old and upwards; the strips should be 1 to 3 inches wide, according to the size of the branch, and 2 to 3 feet in length. They are removed by cutting the bark with an axe and then tearing off by hand. The incision should not penetrate into the wood, and a thin layer of the liber or inner bark should be left covering the wood. About 60 days afterwards, the first collection of gum is made, and after that the garden is completely picked over every fourth day until the rains recommence and new leaves appear on the trees; at this stage the exudation ceases. In Kordofan the rainy season ceases at the end of September, and recommences in the middle of June. Young hashab trees, 8 to 10 feet high and 6 to 8 inches in girth, will produce gum, and the limits of age may be taken as 3 to 15 or 20 years; probably trees of 8 to 12 years are the most productive.

"Talh" or "talha" gum is chiefly collected in the forests of the Blue Nile. There are two varieties of the talha acacia tree, *Acacia Seyal*; the bark of one is covered with a red powder and that of the other with a white powder, and they are consequently known as "red" and "white" talha respectively. Both varieties produce gum, but the red talha is more abundant than the white, and consequently most of the talh gum is derived from

that variety. The talh trees are said not to be barked or wounded by the collectors, who gather the gum they find exuding.

The gum is cleaned from pieces of bark and other dèbris at Omdurman or Khartoum, and a small proportion of it is picked and dried by exposure to the sun on the banks of the Nile and exported as "picked gum," but the bulk of the product is exported in the mixed condition and a portion of it is sorted in European centres, one of the most important of these being Trieste.

The following figures illustrate the importance of the Sudan gum trade, and the share in the exports of Sudan gum taken by the United Kingdom.

Exports of Sudan Gum from Egypt.

Year.	Kilos.	Value. £ (E.)
1885	1,146,879	97,671
1890	7,052	469
1895	149,955	5,856
1900	1,863,072	93,847
1905	8,838,483	217,132
1906	7,689,834	157,330

According to the reports of the Secretary to the Sudan Economic Board for 1907 and 1908, the total exports of gum from the Sudan for these two years were valued at £E154,592 and £E175,269 respectively.

Imports of Gum from Egypt to United Kingdom.

Year.	Cwt.	Value. £
1903	43,334	82,370
1904	32,879	47,168
1905	27,881	41,995
1906	25,599	35,333
1907	38,579	62,530

In 1904 a number of typical samples of gum were submitted to the Imperial Institute by the Sudan Government for examination and for comparison with Senegal gum.

The samples supplied were described as follows:—

"No. 1.—Gum of 1904, Hashab, from Kordofan and Gedarif, gathered between November and June. Ninety per cent. is from Kordofan

"No. 2.—Gum of 1903, Hashab, specially selected and dried.

"No. 3.—Gum of 1903, Gezira, from Gezira and Eastern Sudan, gathered in the dry season.

"No. 4.—Gum of 1903, Talh from Southern Gezira, gathered in the dry season."

Chemical Examination.

The results obtained in the chemical examination of these gums are shown in the following table, which also gives, for

convenience of comparison, the results obtained with commercial samples of Senegal gum of good quality. The results obtained with corresponding qualities of Sudan and Senegal gums are placed as far as possible side by side in the table.

—	Sudanese gum. Hashab, 1904.	Senegal gum. "Gomme du bas du fleuve."	Sudanese gum. Specially selected Hashab 1903.	Senegal gum. "Gomme petite blanche."	Senegal gum. "Gomme grosse blonde."	Sudanese gum. Gezira, 1903.	Sudanese gum. Talh, 1903.
Moisture, per cent. ..	13·2	16·10	11·3	16·1	16·0	12·4	12·2
Ash, per cent.	3·1	3·5	3·3	3·0	3·1	2·7	2·6
Dry matter soluble in water, per cent.	86·5	82·0	87·6	80·6	83·0	87·2	85·2
Acidity (Milligrams of potash required per gram of gum).	2·4	1·9	1·2	0·8	1·2	2·0	2·8
Viscosity of 10 per cent. solution.	31·4	22·5	16·3	32·4	28·7	18·7	25·0
Character of mucilage	Clear, very pale brown. No marked taste or odour.	Opaque, dark brown colour. Slightly bitter.	Clear and almost colourless. No marked taste or odour.	Clear, faintly yellow. No marked taste or odour.	Clear, slightly yellow. No marked taste or odour.	Clear pale yellow. Slight sour odour.	Clear, pale reddish brown. Slight burnt taste.

These results show that the two sets of Sudan and Senegal gums examined were quite normal products, the amounts of "ash" and "matter soluble in water" being quite similar to those usually found in gums of the arabic type. It will be observed, however, that all the Senegal gums contained more moisture than the Sudan products. The greater brittleness of the tears of Sudan gums is due to their drying and becoming permeated by innumerable fissures.

The most important differences between the two classes of gums are, however, shown by the colours and the viscosities of their mucilages. Comparing the "Hashab gum of 1904" and the "Gomme du bas du fleuve," which are both natural unpicked gums, it will be seen that the former is much lighter in colour than the latter, a feature which is to the advantage of the Sudan gum, since absence of a marked colour is a necessity for a number of manufacturing purposes to which gums are applied. On the other hand, the viscosities, that is roughly the "strengths," of the Senegal gums are, on the whole, higher than those of the Sudan products. This difference is very noticeable when the specially selected "Hashab of 1903" is compared with the selected "Gomme petite blanche."

In reporting the results of this comparison of Senegal and Sudan gums to the Government of the Sudan, it was pointed out that though it was unsafe to draw general deductions from the comparison of such a small number of samples, yet there appeared to be some ground for the opinion that Senegal gum was for some purposes superior to the Sudan product, though the latter had the compensating advantages of being cleaner and of lighter colour. A number of suggestions were also made as to

the necessity of systematically examining the gum produced from year to year in the Sudan, so that data could be accumulated for the solution of questions of this kind as they arose, and the suggestion was made that it might be desirable to classify Sudan gum into a larger number of grades before export than at present.

The Sudan gums were submitted for trial to a firm of manufacturing confectioners, who described the "Hashab gum of 1903" (specially selected and dried) as a white clean gum, yielding a very pale, clean, viscous solution and of good flavour; and the "Hashab gum of 1904," as consisting of fine, bold nodules, free from dirt and giving a pale, highly viscous solution, of good flavour and odour, and therefore of special value to confectioners. The "Gezira gum of 1903" was described as yielding a somewhat darker but still satisfactory solution, fairly viscous, with a sourish smell, but good flavour. The "Talh gum of 1903" was regarded as unsuitable for confectioners' use. Commercial experts valued the four products at 35*s.* to 37*s.*, 25*s.* to 26*s.*, 23*s.*, and 18*s.* per cwt. respectively (May, 1904).

Subsequently a small consignment of about one ton of Talh gum was received at the Imperial Institute for analysis and commercial valuation from the Agent-General for the Sudan in October, 1905.

The gum, which was collected in the Sennar Forest, was found to be very similar in appearance to the previous specimen received from the Sudan (*see above*). It consisted chiefly of very small chips and coarse powder, and only a few tears could be picked out. The latter were very friable, and it seems probable that much of the disintegration of the gum took place during transport.

The average colour was pale yellow, but many of the larger pieces were distinctly brown and had a slightly unpleasant taste. The consignment as a whole was clean and free from foreign matter.

The gum was readily reduced to powder, and when treated with water in this state it completely dissolved after a little time giving a medium brown coloured solution which possessed average viscosity and adhesive power. The slight residue of insoluble matter consisted of sand and dirt.

An examination of a representative sample yielded the following results, to which have been added for purposes of comparison those obtained for the specimen previously examined:—

	Present sample.	Previous sample.
Moisture, per cent.	14·2	12·2
Ash, per cent.	3·91	2·66
Portion soluble in water, per cent.	84·6	85·2
Portion insoluble in water „	1·2	2·6
Acidity*	1·8	1·8
Reducing power	slight	very slight

* *Milligrams of sodium hydroxide required to neutralise 1 gram of gum.*

The ash of both samples was identical in appearance, being white and infusible; it consisted of lime with a little magnesia and a trace of iron. The solutions of both gums were brown in colour and yielded similar reactions.

The present specimen is very similar in appearance and properties to the commercial consignments of Talh gum which are met with in commerce.

The gum was offered for sale through brokers in London, and realised 18*s.* 6*d.* per hundredweight (Nov., 1906), which is about the average price for Talh gum in the London market (Nov., 1906).

During a visit to Trieste in 1907 the Director of the Imperial Institute obtained an interesting series of samples comprising (1) natural Sudan gums as imported into Trieste, and (2) graded Sudan gums as produced by the Trieste system of picking. These samples were submitted to a preliminary examination and have given the following results.

Unsorted Gums as imported into Trieste from the Sudan.

No. 50. *Kordofan Gum.*—This is the variety known in the United Kingdom as Kordofan soft gum, and consists of light-coloured pieces which have been "bleached" and dried in the sun. It closely resembles the "specially selected hashab of 1903" referred to above, but is of slightly lower quality, being somewhat more coloured. Viscosity of 10 per cent. solution 22·6.

No. 51. *Gum arabic, natural, cleaned.*—This is Kordofan soft gum, consisting of darker pieces than the previous sample, and has been prepared in the same manner by drying and "bleaching" in the sun. Viscosity of 10 per cent. solution 20·2.

No. 58. *Gum arabic "soft."*—This is a Kordofan soft gum of slightly poorer quality than No. 50, but containing rather less dust and dirt than No. 51. Viscosity of 10 per cent. solution 17·6.

No. 54.—*Gum arabic, sorts.* This consists of glassy tears of gum, which have not been dried. Viscosity of 10 per cent. solution 18·4.

No. 56. *Gum arabic, hard.*—This is "Kordofan hard gum," consisting of hard glassy tears ranging in colour from almost pale yellow to pale reddish brown. Viscosity of 10 per cent. solution 61.

No. 55. *Gezira gum.*—This is collected in the district of Gezira from *Acacia Senegal*, and possibly other species. It consists of a mixture of small pieces of gum ranging in colour from nearly colourless to dark reddish brown. Viscosity of 10 per cent. solution 23.

Graded Gums prepared in Trieste from Sudan Gums.

No. 49. *Grade I.*—Consists of a few whole tears with many fragments. Gum colourless or very pale yellow. A few of the fragments are glassy, but most are nearly opaque owing to the

presence of innumerable fissures on the surfaces of the tears and fragments. The pieces vary in size from fragments $\frac{1}{4}'' \times \frac{1}{8}'' \times \frac{1}{8}''$ to tears $\frac{3}{4}'' \times \frac{1}{2}'' \times \frac{1}{2}''$. Viscosity of 10 per cent. solution 20·7.

No. 48. *Grade II.*—Consists of a few whole, rounded tears with numerous fragments. The gum is pale yellow in colour, but distinctly darker than Grade I. A few of the fragments are glassy, but most of them are opaque due to minute superficial fissures. The pieces vary in size from fragments of about $\frac{1}{8}''$ cube to tears $\frac{3}{4}'' \times \frac{1}{2}'' \times \frac{1}{2}''$. Viscosity of 10 per cent. solution 20·0.

No. 47. *Grade III.*—Contains a fair quantity of whole tears with many fragments. The gum is pale yellow, but of a rather duller tint than either Grades I. or II. It contains a larger proportion of glassy fragments than the first two grades, and the other pieces are less opaque. The pieces vary in size from fragments about $\frac{3}{16}'' \times \frac{1}{4}'' \times \frac{1}{8}''$ to tears $1'' \times \frac{3}{4}'' \times \frac{1}{2}''$. Viscosity of 10 per cent. solution 22·4.

No. 53. *Grade IV.*—Includes a few whole tears with many fragments. The gum is pale yellow and not noticeably darker than Grade III., but the fragments contain rather more dirt and vegetable débris. About one-third of the gum is glassy, and the rest more or less opaque. Size much the same as Grade III. Viscosity of 10 per cent. solution 21·0.

No. 46. *Grade V.*—This differs considerably in appearance from the previous four grades. There are few whole tears, and practically the whole of the gum is glassy. The size is about the same as Grade II., with some dust. Viscosity of 10 per cent. solution 23·0.

No. 52. *Grade VI.*—Consists wholly of fragments of glassy tears, ranging in colour from pale yellow to a medium orange brown. The size varies from $\frac{1}{4}'' \times \frac{1}{8}'' \times \frac{1}{8}''$ to $\frac{1}{2}'' \times \frac{3}{8}'' \times \frac{3}{8}''$, with a little dust. Viscosity of 10 per cent. solution 30·0.

No. 57. *Siftings.*—This consists of dust and very small particles of gum, mostly colourless or nearly so, with a few medium or dark brown particles. Viscosity of 10 per cent. solution 19·4.

It is clear from the foregoing results that in grading gum at Trieste particular attention is paid to bringing out the special qualities of Sudan gum, viz., its light colour and its freedom from dirt, and although attention is also paid to securing uniformity in the size of the pieces included in the various grades, this appears to be considered of less importance than the two factors first mentioned.

The viscosities of 10 per cent. solutions of these samples of Sudan gums are also of some interest. It will be seen that the soft gums have generally a lower viscosity than the glassy hard varieties, and that consequently the grades which consist mainly of the glassy hard gum show increased viscosities (compare Beam, Second Report of the Gordon College Research Laboratories, 1906, p. 229), but with the exception of Samples Nos. 52 and 56, the second of which shows an abnormally high viscosity, all these gums show lower viscosities than the two graded Senegal gums examined at the Imperial Institute in 1905. It has already been

pointed out that the gum produced by the same tree may vary from season to season, and consequently it is unsafe to draw general conclusions from the examination of such a small number of samples as are here dealt with; but it seems certain that the Sudanese method of drying and "bleaching" gum by exposure to the sun in heaps, though it produces a clean and almost colourless gum, apparently has the disadvantage of lowering its viscosity and rendering it extremely friable, and that it would be advantageous if the "bleaching" could be effected by some means which would avoid these defects.*

MOROCCO.

The gum produced in Morocco is stated to be obtained from *Acacia arabica* and *Acacia gummifera*, although according to some authorities much of the gum now exported from that country is merely Senegal or Sudanese gum brought to Morocco by caravans from the interior. The gum is sold in Europe as "Morocco," "Mogadore," or "Brown Barbary gum." The tears are of moderate size, often vermiform, and of a fairly uniform light dusky brown tint; they show numerous superficial fissures.

In 1899 there were exported from Morocco (*via* the ports of Mogadore and Saffi) 450 tons of gum, and in 1900, from the same ports, 545 tons; but these quantities probably include other so-called gums in addition to gum arabic.

The following table shows the quantities and values of Morocco gum arabic imported in recent years to the United Kingdom.

Imports of Gum Arabic to the United Kingdom from Morocco.

Year.	Quantity in cwts.	Value in £
1903	1,451	3,666
1904	1,201	3,019
1905	1,731	3,861
1906	2,073	4,142
1907	2,089	3,959

SENEGAL.

The gum industry of this French Colony is of much more recent growth than that which has existed for centuries along the basin of the Nile, but owing to a variety of favouring circumstances, and especially the stoppage of trade in the Sudan which occurred during the Sudanese Rebellion, it attained in recent years a position which for a time made it a serious competitor to the gum-collecting industry throughout North-East Africa.

* According to Dr. Beam (*Third Report of the Wellcome Research Laboratories*, 1908, p. 483) this type of gum is naturally pale coloured and of low viscosity, and he contends that exposure to the sun is not responsible for these peculiarities.

Senegal gum began to appear in European commerce in the seventeenth century, and for a long time the trade in this product was confined almost entirely to France. In the following century however, it began to be sold in other European countries, and this commerce gradually became more extensive and finally assumed its greatest importance during the rebellion in the Sudan, when competition from Sudanese gum was impossible.

Gum is obtained in Senegal almost entirely from the same tree as in the Sudan, viz., *Acacia Senegal*, but it is probable that the poorer dark-coloured qualities ("Gomme Salabreda") are procured from other species, *e.g.*, *Acacia arabica*, *A. Seyal*, *A. stenocarpa*, *A. Neboueb*, and *A. albida*.

The gum exudes naturally through fissures produced by the rapid and unequal desiccation of the bark of the trees by the hot winds experienced immediately after the wet season, but in recent years the gum collectors have endeavoured to obtain larger yields by making longitudinal incisions in the bark; so increasing the apertures thorugh which gum can exude, and perhaps also stimulating the production of gum in the trees. The cupidity of the collectors has also led them to tap immature trees in this way, and it is stated that if these forcing methods are persisted in, much harm will eventually be done to the gum industry in the colony (*Revue des Cultures Coloniales*, Paris, 1901, p. 62).

The gum is collected from December to February (" petite traite ") and from April to July (" grande traite "), the best material and the largest quantity being obtained during the second of these periods. It is, as a rule, merely broken off the trees by hand, but knives of various kinds, mounted on shafts, are also employed. The collecting is done by Moors and their dependants; these barter the gum to French traders, who transport it principally to St. Louis and Rufisque, though a small quantity also finds its way to Freetown. From these towns it is exported in skins or jute sacks holding from 80 to 90 kilograms.

Three qualities of crude Senegal gum are produced. They are described as follows:—

1. *Gomme du bas du fleuve.*—This quality is produced in the district of Podor in Lower Senegal. It is the best of the Senegal gums, and occurs in large rounded or thick vermiform tears. Its colour varies from almost white through a pale sherry tint to brownish yellow.

2. *Gomme du haut du fleuve.*—This variety is obtained in Fouhlah-land, Guidimaka, and Bambouk, all in Upper Senegal. It ranks second in price, and occurs in rounded, vermiform or branched tears, smaller in size than the first quality, and on the whole darker in colour.

3. *Gomme friable, Salabreda*, or *Sadra beida.*—This, the poorest quality of Senegal gum, consists of small grains (showing a tendency to cohere into masses) and small vermiform tears. The latter are usually only slightly coloured, but the grains are brown.

Senegal gum is almost entirely exported to France (Bordeaux), as the following table shows:—

Exports of Gum from Senegal.

Year.	To France.		To the United Kingdom.		Total.	
	Quantity in cwts.	Value in £.	Quantity in cwts.	Value in £.	Quantity in cwts.	Value in £.
1903 ...	42,526	39,173	242	197	43,261	39,871
1904 ...	45,306	43,496	1,313	1,314	46,652	44,835
1905 ...	49,482	50,776	—	—	49,482	50,776
1906 ...	70,051	64,210	—	—	70,051	64,210

The average price obtained for gum in Senegal in 1897 was £1·95 per cwt.; in the two following years it ranged from £1·65 to £1·67, and in 1900 from £1·84 to £1·89. In 1902 it fell to £1·06, and since then no permanent recovery in prices has occurred.

Very little "grading" of gum is done in Senegal, this branch of the industry being almost entirely managed in Bordeaux, and it has been stated that the popularity of Senegal gum is to a large extent due to the care with which it is "sorted" and "picked" (Wiesner, *Rohstoffe des Pflanzenreiches*). The following is an outline of the scheme of "grading" in use.

The gum is first sorted into "whole" and "broken" tears. The "whole" tears are then picked according to colour, when the following grades result—*Gomme blanche*. This variety is almost colourless. The individual tears are globular and vary in diameter from 1 to 4 cms. (0·4 to 1·5 inches). The surfaces are covered with a network of minute marks, due to the drying of the gum, but the interior portions are glassy and transparent.—*Gomme petite blanche*. This grade resembles the foregoing, but the tears are smaller, varying from 0·5 to 1·5 cms. (0·2 to 0·6 inch) in diameter. *Gomme blonde*, resembling *Gomme blanche* in size but rather darker.—*Gomme petite blonde*, resembling *Gomme petite blanche* in size but a little darker in colour.—*Gomme vermicelle*, including vermiform or branched tears, varying in colour from almost white to pale yellow.—*Gomme fabrique*, consisting of tears, which on account of unusual shape or dark colour are unsuitable for the foregoing groups.

The broken gum is sorted by sifting, and gives the following principal grades; these are each fairly uniform in size, but the colour varies from pale yellow to deep brown:—*Gomme gros grabeaux*, *Gomme moyens grabeaux*, *Gomme menus grabeaux*, *Gomme poussière grabeaux*.

This "grading" applies principally to gum used in France, that re-exported from France to other European countries being usually the first and second qualities of unsorted gum as produced in Senegal. Considerable quantities of the grades "Gomme petite blanche" and "Gomme blonde" are, however, now sent to the United Kingdom.

The following table shows the imports of gum (which may be taken to be mostly of the Senegal variety) to the United Kingdom from France.

Imports of Gum Arabic to the United Kingdom from France.

Year.	Quantity in cwts.	Value in £
1903	10,774	18,105
1904	4,378	7,441
1905	7,360	11,879
1906	11,770	20,096
1907	14,242	24,623

A considerable quantity of Senegal gum is now used in Germany, and the statement has been made that much of it is sold as Kordofan gum in that country. Analyses made at the Imperial Institute of a few typical kinds of Senegal gum are quoted above (p. 154).

NORTHERN NIGERIA.

In this British Protectorate gum and other forest products are collected by the natives and sold to the agents of the Royal Niger Company. The gum so obtained is now a regular article of export to the United Kingdom. In appearance it closely resembles the "Gomme du haut du fleuve" of Senegal, and is usually completely soluble in water and fairly free from dirt. Nothing certain is known as to the botanical origin of this product, but it is probably mainly from *Acacia Senegal*. The following tables show the quantities and value of gum exported from the Protectorate in recent years, and the imports of this product to the United Kingdom (*via* Liverpool).

Exports of Gum Arabic from Northern Nigeria.

Year.	Quantity in cwts.	Value in £
1905	4,140	3,728
1906	6,080	6,080

Imports of Gum Arabic from Northern Nigeria to the United Kingdom.

Year.	Quantity in cwts.	Value in £
1903	2,833	3,116
1904	3,130	2,992
1905	4,041	4,849
1906	5,379	5,913
1907	5,588	6,299

A number of samples of this gum have been received at the Imperial Institute for examination, and the results obtained are grouped together in the following table:—

Results of Examination.

	Sample received in 1903.	Samples received in 1904.				Sample received in 1905.	Sample received in 1907.
—	Gum from Borgu.	Gums from Geidam.	Gums from Garfung, Kano.			Gum from Bornu.	Gum of *Acacia caffra* from Kontagora.
			1	2	3		
Moisture, per cent. ..	14·5	14·0	27·8	17·8	17·4	15·0	17·7
Ash, per cent. ..	2·26	2·9	2·6	2·6	3·2	3·1	2·6
Dry matter soluble in water, per cent.	82·2	86·0	82·0	79·0	78·0	85·0	81·2
Acidity*	0·0	1·6	2·0	0·8	0·8	traces	—
Reducing sugars, per cent.	0·0	—	traces	1·2	traces	*nil*	—
Relative viscosities of 10 per cent. solutions	22	21·0	14·2	21·2	22·5	21·8	10
Colour of mucilage (10 per cent.).	pale yellow	almost colourless	almost colourless	pale brown	pale brown	pale yellow	almost colourless

* Milligrams of potassium hydroxide required to neutralise one gram of gum.

It will be seen that most of these Nigerian gums differ but little from the average quality of unsorted Sudan gum. Several of the samples exhibit a rather low viscosity, but the colour is generally good, and the samples are as free from dirt as average Sudan gum. In all cases the mucilages prepared from the gums are strongly adhesive. The sample derived from *Acacia caffra* from Kontagora is interesting as showing that gum of good quality is obtainable in Nigeria from other species than *Acacia Senegal.*

Gold Coast Colony.

There is no organised production of gum in this Colony, and the extent to which gum-yielding trees occur is not known.

The three samples of gum now dealt with were forwarded for examination by the Inspector of Agriculture for British West Africa in April, 1908.

The samples were as follows:—

Gum of *Acacia Sieberiana.*—This consisted of pale yellow to yellowish-brown, irregularly shaped tears with some dust and a few roughly cylindrical pieces measuring $1\frac{1}{2} \times \frac{3}{8} \times \frac{3}{8}$ inch. The largest fragment in the sample weighed 18 grams, but most of the pieces were quite small.

Gum of *Burkea africana.* This consisted of small, uniform, pale yellow to reddish-brown, semi-transparent tears, mixed with a small amount of woody matter.

Gum of *Pseudocedrela Kotschyi.*—This consisted of small pale yellow to yellowish-brown tears. The sample contained some large pieces of bark to which fragments of gum adhered.

The botanical determinations given above were made at Kew on herbarium specimens forwarded to the Imperial Institute with the samples of gum.

The chemical examination of the samples gave the following results:—

Botanical Origin.	Acacia Sieberiana.	Burkea africana.	Pseudocedrela Kotschyi.
Moisture, per cent.	14·9	15·06	13·7
Ash, per cent....	1·8	2·3	2·6
Insoluble matter, per cent. ...	7·02	0·9	0·35
Reducing sugars, per cent. ...	Traces.	—	Considerable traces.
Relative viscosities of 10 per cent. solution.	27·0	18·2	10·8
Acidity*	3·6	3·92	3·1
Colour of mucilage (10 per cent. solution).	Yellowish brown and turbid.	Dark brown.	Yellowish brown and turbid.
Taste of mucilage	Almost tasteless.	Pleasant taste.	Almost tasteless.

* Milligrams of potash required per gram of gum.

Conclusions.

Of these gums that from *Acacia Sieberiana* is the most likely to be saleable in the United Kingdom at remunerative rates. That from *Burkea africana* is of fair quality but rather dark in colour, and for this reason it would realise low prices. The product of *Pseudocedrela Kotschyi* is a soluble gum somewhat resembling the Sudanese talh gum, but is of inferior quality as compared with this.

These three gums are all rather inferior to the gum of *Acacia Senegal* as now exported in large quantities from the Sudan, Senegal, and Northern Nigeria. The products would, however, all be saleable though those of *Burkea africana* and *Pseudocedrela Kotschyi* would probably only bring about 15 or 16 shillings per cwt. Unless, therefore, these gums are readily obtainable in large quantity it is not worth while to take further action regarding them, but if the trees yielding any of them occur commonly distributed over wide areas, so that the gum could be collected from them cheaply, they might be worth further attention (November, 1908).

ORANGE RIVER COLONY.

Acacia horrida occurs in this Colony, and gum is occasionally collected from it for local use.

A sample of this material was received at the Imperial Institute for examination in 1907. It consisted of hard, brittle, pale yellow, sub-angular or irregular tears, and was free from dirt. On analysis the following results were obtained:—

	Per cent.
Ash	2·99
Moisture	18·06
Dry matter soluble in water	81·84

The mucilage was rather dark in colour, and was about twice as viscous as mucilage of good Sudan gum of similar strength. Its taste was sour and rather unpleasant, and the adhesive properties were poor. A firm of manufacturing confectioners to whom a sample of the gum was submitted stated that it resembled Aden gum, but would be of no value for confectionery on account of its marked taste. The sample was valued by brokers at 15*s.* per cwt. (June, 1907).

Portuguese East Africa.

There is no organised production of gum in this Portuguese Colony, but as in German and British East Africa gum-yielding trees are of common occurrence.

A sample of gum from this area was included in a collection of botanical products from Beira forwarded to the Imperial Institute by the London Manager of the Mozambique Company in February, 1906.

The sample was described as "probably from an acacia, exuded naturally from trunks of several large trees." It consisted of dark brown, almost black, irregular fragments, to some of which large pieces of bark adhered. A small amount of light coloured gum was intermixed with the dark fragments. The gum was hard, and somewhat brittle when chewed.

Both the light and dark coloured portions were readily soluble in cold water. A 10 per cent. solution of the former was almost colourless, and rather more viscous than a similar solution of Sudan gum arabic of good quality. An analysis of the gum gave the following results:—

	Light coloured gum.	*Dark coloured gum.*
Ash	1 per cent.	1·9 per cent.
Insoluble matter ...	trace	4·55 ,,
Moisture	—	11·5 ,,
Acidity	1 gram requires 1·68 mgm. potash.	

The solution gave no coloration with ferric chloride and no precipitate with lead acetate or Fehling's solution.

The results of the examination show that this gum is of promising quality, but it is too dark, and contains too much extraneous matter (bark, &c), to be submitted to buyers for valuation. The dark colour of the sample is probably due to the gum having been scorched by bush fires. Information is needed as to the species of Acacia from which the gum is obtained (May, 1908).

Uganda.

Gum from the fruits of *Balsamocitrus Dawei*, Stapf.

A specimen of this material was sent to the Imperial Institute by the Officer-in-charge of the Forestry and Scientific Department, Uganda Protectorate, in January 1906. The product was

stated to occur surrounding the seeds in the fruits of *Balsamocitrus Dawei*, Stapf., a recently-discovered plant belonging to a new genus.

Description of sample.—Two small quantities of the substance, contained in stoppered bottles, were received. These two specimens differed slightly in appearance, one being faintly opalescent whilst the other was almost clear, but both possessed a faint, characteristic, aromatic odour, recalling that of citronellal, and a sweetish acid taste. As the total quantity was small it was necessary to mix the two specimens in order to obtain sufficient material for chemical examination.

Chemical examination.—The material was steam distilled, and the distillate and residue were examined separately.

The distillate was a slightly opalescent liquid which possessed the characteristic odour of the original substance. Only traces of volatile oil were found in it.

The residue was completely soluble in water, and had all the properties of an ordinary gum of the acacia type. It also contained a small quantity of a sugar.

Conclusions.

This substance is a gum-like secretion containing a very small quantity of volatile oil. It is extremely doubtful whether any commercial use could be found for this product, even if it could be obtained in a fairly dry form suitable for transport and in large quantities (which from the mode of its occurrence seems unlikely) since the slight odour would prevent its use for most of the purposes to which gums of the acacia type are applied.

SOMALILAND AND ABYSSINIA.

Aden and East Indian gum.

The gum produced in Abyssinia and Somaliland, especially in the districts of Gardafui and Ogaden, is exported from the towns on the Somali coast, principally to Aden and Bombay. From these two ports it is re-shipped to Europe as "Aden gum" and "East Indian gum" respectively. Abyssinian gum is almost entirely exported *via* Harrar.

It is impossible to say with certainty from what species this gum is obtained, but some of it is doubtless collected from *Acacia abyssinicia* and *Acacia glaucophylla*, which are known to occur in those regions.

The best qualities of Aden and East Indian gum approach the better classes of Kordofan gums in appearance, solubility, &c., but these gums as a whole are darker in colour. The following tables show the extent of this trade. At present Aden gum is worth from 25 to 30*s*. per cwt. in London (May, 1908).

Imports of Gum Arabic to Aden.

Year.	Quantity in cwts.	Value in £.
1903–4	4,966	4,588
1904–5	4,093	3,433
1905–6	9,690	9,084
1906–7	8,856	8,089
1907–8	6,447	6,341

Re-exports of Gum Arabic from Aden.

Year.	Quantity in cwts.	Value in £.
1903–4 to Foreign ports	3,576	4,524
to Indian "	1,618	1,423
1904–5 to Foreign "	2,039	2,793
to Indian "	3,700	4,135
1905–6 to Foreign "	1,758	2,408
to Indian "	8,383	9,805
1906–7 to Foreign "	1,812	6,432
to Indian "	8,859	9,423
1907–8 to Foreign "	357	478
to Indian "	7,093	8,990

Imports of Gum Arabic to India.

Year.	Quantity in cwts.	Value in £.
1903–4	2,404	2,421
1904–5	4,691	4,191
1905–6	11,305	10,291
1906–7	10,127	10,281
1907–8	8,085	8,451

Re-exports of Gum Arabic from India (East Indian Gum).

Year.	Quantity in cwts.	Value in £.
1903–4	13,446	13,306
1904–5	8,147	8,816
1905–6	3,967	4,882
1906–7	2,684	3,827
1907–8	3,010	3,439

INDIA.

Ghati gum.

This name is applied generally in India to the gum produced in India itself, as distinguished from East Indian gum of exotic

origin (*see above*). In European commerce, however, the name "Ghatti" or "Gatty" is practically restricted to the partially soluble and highly viscous gum derived from *Anogeissus latifolia* and certain other species. It is obtained from a variety of trees, and no attempt is made to keep the products of the different species separate. The result of this is that consignments of Indian gum may vary considerably in properties. This state of things could be improved if a proper system of "sorting" and "grading" Indian gums were introduced, but so far nothing of this kind has been attempted on a scale large enough to modify its unsatisfactory character. Some of the more important sources of Indian gums are *Acacia modesta*, yielding the so-called "Amritsar gum; *Acacia arabica*, furnishing "amrad" or "Amrawatti" gum; *Acacia Senegal*; *Odina Wodier*, furnishing "jingan" gum; *Anogeissus latifolia*, one of the principal sources of "Ghati" gum, and *Acacia catechu*.

The gums yielded by these trees appear to be collected in India in a very haphazard fasion; thus Captain Tighe, in his Report on South Baluchistan (*Agricultural Ledger*, 1902, No. 2, p. 76) states, with regard to the gum of *Acacia Senegal*: "There is no regular collection of the gum. Women and children occasionally collect a little and barter it to the banias for anything they may want. The latter accumulate whatever is brought until they have sufficient to take to Karachi. The collection is thus made casually by banias, who sell it to the leading native firms in Karachi, who in turn sell it to the European merchant." In some cases gum collectors are charged a nominal sum (usually one anna per day) for the privilege of collecting forest produce, including gum, in the conserved areas, but apart from this no taxes are levied.

In spite of these unsatisfactory conditions, the trade in Indian gum has assumed considerable dimensions, and if steps were taken to encourage the growth of a few of the best gum-yielding species, and a proper system of collecting, sorting, and grading the gums were instituted, there can be no doubt that a large export trade could be developed.

A number of samples of Indian gums have been examined at the Imperial Institute, and the results obtained with the more important of these are given in the table on page 169.

These results are of little interest from a commercial point of view, since Indian gum of commerce consists generally of mixtures of the products of different species; but they are interesting as showing that it would be advantageous to keep these products separate. Of the nine gums examined, probably five, viz., those from *Prunus eburnea*, *Acacia Jacquemontii*, and *Elæodendron glaucum*, would rank commercially as gums of the first grade, whilst those from *A. catechu*, *A. arabica*, *A. Farnesiana*, and *A. modesta* would probably sell as second-grade products. The results obtained with *Anogeissus latifolia* gum are similar to those obtained with the best grades of Ghati gum which reach the United Kingdom. Analyses of the gums of *Bauhinia retusa* and *Odina Wodier* have been published already in "Technical Reports and Scientific Papers" issued by the

Imperial Institute in 1903. These are both soluble gums of the second grade.

The following table shows the quantities and values of Indian gum arabic (Ghati gum) exported in recent years.

Year.	Quantity in cwts.	Value in £
1902-3	38,019	30,309
1903-4	39,760	33,499
1904-5	28,377	28,974
1905-6	32,664	36,908
1906-7	35,202	44,617
1907-8	37,431	44,608

The present value of Ghati gum in this country is about 18*s*. 6*d*. for inferior to 28*s*. 6*d*. for the best grades (May, 1909).

Results of Examination.

	Acacia Jacquemontii.			*Prunus eburnea.*†		*Elæodendron glaucum.*	*Acacia catechu.*		*Acacia arabica.*	*Acacia Farnesiana.*	*Acacia modesta.*	*Acacia Senegal.*	*Anogeissus latifolia.*	
	From Amritsar.	From the Punjaub.	From the Punjaub.	From Baluchistan										
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent	Per cent.	Per cent.
Moisture ...	18·5	18·5	14·8	14·8	14·7	15·2	15·7	16·8	15·0	13·8	16·2	16·3	15·5	16·1
Ash	3·53	3·5	2·84	2·54	2·35	2·59	3·24	2·87	2·27	1·83	2·69	2·68	2·41	3·11
Dry matter soluble in water.	80·02	81·9	84·0	80·7	79·1	82·0	82·4	81·2	78·6	85·40	85·0	84·0	78·2	71·5
Acidity* ...	4·0	3·2	4·8	0·8	1·2	—	—	—	—	—	—	—	—	—
Character of mucilage.	Faintly opaque, slightly yellow, adhesive.	Clear, faintly yellow.	Slightly yellow.	Fine clear colourless adhesive solution.		Clear, very slightly yellow.	Clear, light reddish-brown.	Light yellowish-brown.	Clear, pale reddish-brown.	Clear, pale yellowish-brown.	Clear, pale yellow.	Clear, faintly yellowish-red.	Viscid, pale yellowish-brown.	Viscid yellow solution.

* Milligrams of potassium hydroxide required for one gram of gum.

† In some respects this product resembles "Persian insoluble" gum, and might perhaps be included in that group if it came into commerce in quantity.

The principal markets for Ghati gum in order of their importance are Germany, the United Kingdom, Belgium, and France.

AUSTRALIA.

Throughout the Commonwealth of Australia gum is collected from various species of acacia known locally as "Wattles." The principal species are *Acacia pycnantha*, *Acacia decurrens*, *Acacia neriifolia*, and *Acacia homalophylla*. Wattle gum occurs in large hard globular tears occasionally of a pale yellow colour, but usually amber or reddish-brown. It is transparent and highly adhesive, and is, therefore, particularly suitable for adhesive purposes. These gums are extensively used in Australia, and were formerly exported in considerable quantities to the United Kingdom and Germany, but the imports to the United Kingdom which amounted to 2,150 cwt., valued at £3,368 in 1898, fell to nearly half that amount in 1900, and in 1907 only 534 cwt., valued at £1,964 was imported, that being a slight increase on the imports of the four preceding years.

The imports came at first principally from New South Wales, but more recently South Australia took the largest share in this export trade.

"INSOLUBLE" GUMS.

The most important member of this group, and the only one which regularly occurs in commerce, is tragacanth gum. At the request of the Board of Agriculture of Bermuda the following memorandum on this gum was prepared in 1908.

Tragacanth gum.

Tragacanth is obtained from several species of Astragalus, some of which occur in South-Western Europe, whilst others are found in Greece and Turkey. The largest number, however, are indigenous in the mountainous regions of Asia Minor, Syria, Armenia, Kurdistan, and Persia. The tragacanth of commerce is produced in the last-named countries, and chiefly, though not exclusively, by the following species:—

Astragalus adscendens, Boiss. et Hausskn., a shrub attaining 4 feet in height, a native of the mountains of South-Western Persia, at an altitude of 9,000 to 10,000 feet. According to Haussknecht it affords an abundance of gum.

A. leioclados, Boiss., Persia.

A. brachycalyx, Fisch., a shrub 3 feet high growing on the mountains of Persian Kurdistan.

A. gummifer, Labill., a small shrub of wide distribution, occurring on Lebanon and Mount Hermon, in Syria; also in Armenia and Kurdistan.

A. microcephalus, Willd., like the preceding, a widely distributed species extending from the South-West of Asia Minor to the North-East Coast, and to Turkish and Russian Armenia.

A. pycnocladus, Boiss et Hausskn., nearly related to *A. microcephalus*, occurs on the high mountains of Avroman and Shahu, in Persia. Haussknecht states that it yields gum in abundance.

A. stromatodes, Bunge, growing at an elevation of 5,000 feet on the Akker Dagh Range, near Marash, in Asia Minor.

A. kurdicus, Boiss., a shrub 3 to 4 feet high, native of the mountains of Silicia and Cappadocia, extending thence to Kurdistan. Haussknecht states that from this and *A. stromatodes* the so-called Aintab tragacanth is obtained.

The gum is also collected to some extent from *A. verus* in North-Western Persia and Asia Minor. This species is stated to be abundant in Persia between Hamadan and Kermanshah.

A. Parnassi, Boiss., var. *cyllenia*, a small shrub found in abundance on the northern mountains of the Morea.

The tragacanth shrubs thrive in the wild state in the mountain ranges of dry sub-tropical countries; the soils in the districts referred to are all highly calcareous.

In July and August, the shrubs are stripped of their leaves, and short longitudinal incisions or slits are made in the trunks. According to a British Consular Report on the trade of Kermanshah, 1903-1904, No. 3189, page 28, "the top of the plant is burnt, and when the leaves are all consumed the fire is put out and incisions are made." The gum flows out, and, drying spontaneously, is ready for gathering in three or four days. If the weather is fine during the drying process, the "white leaf" form of gum is obtained; this is the most prized variety. If, on the other hand, rain falls, or the wind rises, particles of dust are carried into the surface of the gum which thereby loses its whiteness, and becomes the "yellow leaf" form, the second quality. The shape of the incision, of course, determines the form of the pieces; longitudinal incisions produce "leaf" or "flake" tragacanth, punctures yield "thread" tragacanth, while irregularly-shaped incisions give knob-like masses, generally coloured, and of relatively low value. Another form, known in Persia as "Arrehbor," exudes from branches, which have been cut with a saw. In Persia the productive life of the shrub is 7 years.

Smyrna is an important market for gum tragacanth; it is conveyed to that port by native dealers, who purchase it from the peasants, in bags containing about 2 quintals each. It is there sorted into the various qualities in order to fit it for the European market, packed into cases containing about two hundredweight. and shipped to London, Marseilles, or Trieste. Basra (near the mouth of the Euphrates) is also an important port of shipment.

The exports of tragacanth from Smyrna are given in the following table:—

Exports of gum tragacanth from Smyrna.

Year.	Cwts.	Value in £
1901	1,660	4,040
1902	3,000	9,577
1903	2,600	6,237
1904	2,300	5,104
1905	1,180	8,165
1906	880	5,369

The current prices for gum tragacanth in the London market vary from £1 10s. to £16 10s. per cwt., according to quality, but these prices are rather higher than those usually obtained for the gum which has been for some time scarce and dear.

Complete figures of exports from Persia are not available, but in 1907 the value of the exports of tragacanth from Bunder Abbas was £13,937, from Bushire, in 1907-08, they were worth £76,577. There is also a considerable export of gum from Basra, which doubtless includes some tragacanth. In 1907 the value of the gum shipped from this port was £14,388.

GUM OF *Cochlospermum Gossypium* FROM INDIA.

Various other "insoluble gums" are collected in different parts of the world, but they are not so highly valued as tragacanth. In India the gums of *Cochlospermum Gossypium* and of *Sterculia urens* are sold as substitutes for tragacanth.

An examination of the gum of *Cochlospermum Gossypium* has been made by Mr. H. H. Robinson, of the Scientific and Technical Department of the Imperial Institute, and the results were communicated at the York meeting of the British Association for the Advancement of Science, and a fuller account of the investigation was published in the *Journal of the Chemical Society* (1906, **89**. 1496).

Cochlospermum Gossypium is a small deciduous tree belonging to the Bixiniæ; it grows abundantly in the forests of the North-West Himalaya, and extends across the central tableland of India.

The gum occurs in irregular, rounded, translucent lumps of a pale buff colour; like tragacanth, it absorbs a large quantity of water, and swells to many times its original size. It is remarkable among the gums for its property of slowly giving off acetic acid when exposed to moist air; this property is also possessed by the gum of *Sterculia urens*. The gum was found to yield 14 per cent. of acetic acid; unlike tragacanth, it does not give any blue coloration with iodine, and is, therefore, free from starch.

By the action of cold 5 per cent. sodium hydroxide solution, a solution of the gum is obtained which, when neutralised with acid and submitted to dialysis, yields a clear viscous liquid containing a substance, which has been named "cochlosperminic acid." If the viscous liquid is evaporated, clear transparent flakes are obtained which resemble the original gum in being insoluble in water, but no longer contain acetic acid, as this acid has been removed by the sodium hydroxide.

By the action of hot dilute sulphuric acid the gum is decomposed into acetic acid, various sugars and a nucleus acid, gondic acid, which, like gum arabic, is soluble in water, and possesses adhesive properties.

This work suggests the possibility of preparing products of industrial value by the chemical treatment of various gums of this type.

NYASALAND.

A sample of gum from this Protectorate was received at the Imperial Institute, 1903.

It was stated in the accompanying descriptive report to be collected by the natives from several different trees which have so far not been identified.

The sample consisted of about ½ lb. of small fragments of translucent gum, varying in colour from light yellow to deep brown. It had a slight odour of acetic acid, but possessed no peculiar taste.

On analysis the following results were obtained:—

	Per cent.
Amount soluble in water	32·8
Moisture	15·6
Ash (magnesium and calcium carbonate with a trace of ferric oxide)	2·57

The portion of the gum insoluble in water swelled up into a translucent jelly in contact with this liquid.

This gum resembles those obtained from the Indian tree *Cochlospermum Gossypium* and the Australian plant *Sterculia acerifolia* in being only partially soluble in water and in slowly evolving acetic acid when exposed to the air (see above, p. 172).

Insoluble gums of this class have at present no commercial value unless they can be obtained, like the well-known insoluble tragacanth gum, almost free from colour.

UGANDA.

GUM OF *Albizzia Brownei*.

A sample of gum collected in the Bukedi District of Uganda was forwarded to the Imperial Institute by the Officer-in-charge of the Botanical, Forestry, and Scientific Department at Entebbe in June, 1907.

The gum is known locally as "Nongo," and is derived from a small tree, which has been identified as *Albizzia Brownei*. It was stated that the gum is procurable in large quantities in many parts of Uganda, and it was consequently desired to know whether it was of commercial value.

The sample weighed about one cwt., and consisted of irregular dark-brown tears and aggregations of tears varying in weight from ½ lb. to ¼ oz. or less, and in most cases containing a considerable proportion of woody impurities. The gum was very hard and difficult to powder.

Chemical examination furnished the following results:—

	Per cent.
Ash	4·6
Moisture	16·9
Dirt	2·7

The gum was not readily dissolved by water, and in order to obtain complete solution it was necessary to allow a small quantity of the powdered material to remain in contact with much water for 4 or 5 days with frequent shaking. The solution formed was rather gelatinous, and was so thick that a one per cent. solution had approximately the same viscosity as a 20 per cent. solution of good Sudanese acacia gum.

The one per cent. solution, which was used for the comparison of the viscosity, was cloudy, nearly colourless, and had a feebly acid reaction. A 2 per cent. solution in water furnished a thin jelly, in which a proportion of the gum, equivalent to 10 per cent. of the whole, did not dissolve, but simply swelled up.

Gum of this type, which would be classed commercially as "insoluble," can be sold at low rates in London when it is light-coloured, but a brown gum, such as the present sample, would be practically unsaleable (October, 1907).

Portuguese East Africa.

This sample of insoluble gum was received from the Mozambique Company in October, 1907. It was labelled No. IX., and was said to have been collected from a large indigenous tree. It consisted of yellowish-brown, round or sub-angular tears, which were fairly free from dirt.

This gum is of an insoluble type, and when treated with water does not completely dissolve, but swells up and forms a jelly. It would be unsaleable except at such low rates as would certainly be unremunerative (March, 1908).

Gold Coast Colony.

Included with the three soluble gums, described on p. 162, and received from the Inspector of Agriculture for West Africa in April, 1908, were two samples of "insoluble" gum from *Combretum undulatum*.

No. 1 consisted of a flattened, sub-angular, brownish mass together with two or three small fragments. It furnished 4·6 per cent. of ash, and when placed in water formed a jelly.

No. 2 consisted of pale yellow to dark brown tears, many of which were vermiform. The sample contained a good deal of bark and other vegetable débris. It furnished 5·2 per cent. of ash, and formed a jelly with water.

These gums being dark coloured and insoluble would be of no commercial value at present.

SEMI-INSOLUBLE GUMS.

The typical product of this class is the "Persian insoluble gum" of trade which is largely exported along with tragacanth gum from Basra and other ports in the Persian Gulf. Very little is known of the origin of this gum or as to the localities in which it is collected, but according to a note published in the Kew Bulletin in 1906 it is probably in part derived from *Amygdalus leiocarpus.* The gum is of a hard glassy type, and its solutions in water are intermediate in character between those of tragacanth and gum arabic, *i.e.,* they form thin jellies. The commercial value of this gum is lower than those of either tragacanth or fine gum arabic, and when the prices of the latter are low it is difficult to sell in European markets.

The trade in "Persian insoluble gum" is considerable, but exact figures cannot be given, as the exports of gum from Basra (see page 172) probably include tragacanth as well as this variety. The exports of this type of gum from Bushire in 1906-07 were valued at £65,967, and in 1907-08 at £5,415. This class of gum is probably also included in the gum exports from Bunder Abbas and Lingah.

The value of Persian insoluble gum in London at present is about 15*s.* per cwt. (May, 1909).

The following reports deal with samples of gum which, if placed on the market, would probably be classed in commerce with these Persian "insoluble" gums, but they are darker coloured than this class of gum as a rule, and consequently they would not be readily saleable except when better gums are scarce and dear.

NORTHERN NIGERIA.

A sample of gum from Bassa Province was included in a collection of vegetable products sent to the Imperial Institute for examination in 1903.

It consisted of two large tears, weighing about 1 oz. each, of translucent, yellowish-brown gum, presenting slightly fissured surfaces.

The following table gives the results obtained on analysis of this gum:—

	Per cent.
Moisture	15·4
Ash	2·42
Amount soluble in water	76·6
Acidity	0·0

The mucilage obtained by solution of the gum in water was precipitated by alcohol and by a solution of basic lead acetate, but not by solution of ferric chloride, and in these respects it resembled mucilage prepared from gum arabic, but, unlike the latter, it was only slightly adhesive when applied to paper. The insoluble portion of the gum swelled into a translucent jelly in contact with water.

A gum of this type would be classed by brokers as "insoluble," and on account of its rather dark colour would have little, if any, commercial value.

GOLD COAST COLONY.

The collection of gums sent from this Colony to the Imperial Institute in April, 1908 (see p. 162), also included one of unknown botanical origin, which was of the "semi-insoluble" type.

It consisted of a single, elongated, flattened, opaque mass varying in colour in different parts from yellow to dark brown. On analysis it gave the following results:—

Moisture	13·6
Ash	4·6
Viscosity of 5 per cent. solution ...	20·0
Acidity	10·6
Colour of mucilage	brown and turbid.
Taste of mucilage	rather sour.

This gum would be classed as semi-insoluble, and on account of its dark colour and sour taste would not be saleable in competition with "Persian insoluble" gum.

UGANDA.

This sample of gum was received from the Government of Uganda by the Crown Agents for the Colonies, and was transmitted by them in September, 1903, to the Imperial Institute in order that its commercial value might be ascertained. No information regarding the botanical origin of the gum was given, but it was stated to have been collected in the vicinity of the Anglo-German boundary.

The specimen consisted of large, irregularly-shaped, tears of dark reddish-brown gum. It possessed no characteristic odour or taste.

The gum contained 16·1 per cent. of moisture, and yielded on ignition 1·85 per cent. of ash, consisting principally of potassium, calcium, and magnesium carbonates, with a trace of ferric oxide. It contained a very small quantity of free acid.

The gum was incompletely soluble in water, which dissolved only 46·1 per cent. of the whole. The insoluble portion did not gelatinise when in contact with water. The aqueous extract was a clear light-brown liquid, which gave no precipitate on the addition of a solution of neutral or basic lead acetate, or of ferric chloride, but was precipitated on the addition of alcohol. The solution of the gum contained no sugar, and was not adhesive.

These results indicate that the gum belongs to the class of partially soluble gums for which the commercial demand is comparatively restricted, and this circumstance, taken in conjunction with its dark colour, renders it unlikely that this material could be profitably exported.

There is reason to believe that certain varieties of acacia trees, which produce light-coloured soluble gums in the earlier stages of their growth, produce, when mature, dark coloured insoluble gums of quite different type. It may be the case that this Uganda gum was derived from old acacia trees, and that further examination of the gum of younger trees may result in the discovery of a product of better colour and greater solubility. If this should appear likely, further samples should be sent for examination.

RESINS.

INTRODUCTION.

The name resin is applied to a great variety of products which it is impossible to include in any single definition. Like gums they are usually obtained as the result of exudation from plants, and in many ways they resemble gums in appearance. Thus they are usually pale yellow to brown in colour, are transparent or translucent, and when freshly broken appear to be homogeneous and continuous in structure. They can, however, be readily distinguished from "true gums" by the following simple methods.—

(1) When a resin is held in a flame it takes fire and burns with a smoky flame, giving off at the same time an aromatic odour. A gum similarly treated does not take fire but chars, and smells of burnt sugar.

(2) A resin placed in water remains unchanged, whereas a gum either dissolves, forming a thick liquid, or absorbs the water completely, forming a jelly.

(3) When a resin is allowed to stand in spirits of wine or oil of turpentine it disintegrates, and either dissolves partially or completely. A gum, on the contrary, is entirely unaffected by either of these solvents.

USES OF RESINS.

Industrially resins are applied to a great variety of purposes, but probably the most important of these is the manufacture of varnishes and lacquers. Such varnishes may conveniently be divided into the two classes—"oil varnishes" and "spirit varnishes."

The former class consists essentially of a combination of a resin with linseed oil, diluted with turpentine oil to the proper thickness. A typical product of this group is "copal varnish."

The second class comprises solutions of resins in spirits of wine, oil of turpentine, or other volatile solvents. Typical examples are dammar, mastic, and shellac varnishes.

The cheapest of all resins, viz., colophony or "common rosin," *is largely used in the manufacture of soaps, and in recent years the compounds which rosin forms with metals* such as aluminium, zinc, and manganese have come into extensive use under the name "resinates," especially for the preparation of quick drying varnishes, and "driers" to be added to oil varnishes in order to improve the "drying" properties of the latter.

Certain resins, such as shellac, find subsidiary but still important applications as finishing materials for certain textile goods, in the preparation of lithographic inks, and as ingredients in certain kinds of cements. Others are used as incense resins, and a considerable number of drugs, such as Indian hemp, owe their therapeutic value to the presence of resinous constituents.

The industrial importance of this group of products is made clear by the fact that the total value of the imports of resinous materials into the United Kingdom in 1908 was £2,803,535. Of this amount £1,731,851 came from various parts of the British Empire and £1,071,684 was derived from foreign sources.

METHODS OF INVESTIGATION.

Very little work has been done as yet on the chemistry of resins, and consequently methods for their examination are not so well systematised as in the cases of some other natural products, such as fatty oils. Further, the resins as a class are complex materials, and often consist of mixtures of substances apparently widely different in properties, and consequently do not lend themselves to a general method of analysis, such as is possible in the case of rubbers, where the material apart from impurities consists for the most part of one substance, or at least a few very closely related substances, almost identical in properties. As a rule, the following points are of importance in the analytical examination of resins:—

1. *Percentage of ash.*—This should, as a rule, be negligible. A large amount of ash indicates the presence of inorganic impurities.

2. *Melting point.*—This constant is of special importance in the case of copals. The fossil, or hard copals, have very high melting points, whereas the "half hard" and "soft" kinds, which are much less valuable, melt at low temperatures.

3. *Range of solubility.*—Observations on the range of solubility of resins in organic solvents are of great value in enabling a distinction to be drawn both between classes of resins and between members of the same class. Thus Zanzibar copal has a much smaller range of solubility than such inferior kinds as Nigerian copal.

4. *Acid number.*—This constant, defined as the number of milligrams of potassium hydroxide required to neutralise one gram of resin, is often useful as a means of distinguishing one type of resin from another. Thus common rosin has a higher acid number than most of the other commercially valuable resins.

5. *Colour.*—This is almost always an important factor in determining the value of a resin. Generally speaking, the palest coloured and most transparent resins of any one class fetch higher prices than those that are dark coloured and only translucent, or even cloudy.

Resins Examined at the Imperial Institute.

In the volume of "Technical Reports and Scientific Papers," published at the Imperial Institute in 1903, the only resinous products dealt with were (1) "Indian frankincense" derived from *Boswellia serrata* (Part I., page 162), which was shown to be similar in quality to the olibanum largely used as incense, and obtained from various species of *Boswellia* inhabiting the eastern horn of Africa; (2) Podophyllin resin, obtained from *Podophyllum Emodi*, a plant indigenous to Northern India, which was proved to be equal in value to American podophyllin resin as a therapeutic agent, and has since that time been recognised by the General Medical Council for use in India and the East Indian Colonies in place of the American resin (*loc. cit.*, Part II., page 1); and (3) Australian sandarac resin, which was found to contain the same constituents as the sandarac resin of commerce obtained from Morocco, and to be equally valuable as a varnish resin. In the present series of reports a much wider range of products is dealt with, and these may, for convenience of discussion, be classified into the following groups:—

A.—Copal.
B.—Dammar.
C.—Natural varnish.
D.—Elemi.
E.—Colophony.
F.—Miscellaneous.

COPAL.

The chief sources of copal are East Africa, West Africa, the Dutch East Indies, certain islands in Polynesia, New Zealand, New Caledonia, and the North-Eastern parts of South America.

The East African product is collected in German, British, and Portuguese East Africa, and is usually sent thence to Zanzibar, where it is sorted, cleaned, graded, and packed for export. It is known in commerce as Zanzibar animi or copal, and varies in price from £30 per ton for dust to £340 per ton for the best quality. The exports from Zanzibar in 1906 were valued at £14,390, of which 90 per cent. went to the United Kingdom.

A similar copal is collected to a small extent in Madagascar, and is shipped to France. These East African copals are fossil kinds, and are found chiefly in localities from which copal trees have now disappeared.

The West African material is obtained throughout the coastal region of the Continent from the British Colony of Sierra Leone to the Portuguese Congo territory, and is of very variable quality, the best sorts being fossil or semi-fossil, and the medium and poorest qualities being procured from living trees. The best West African copals at the present day are those from the Congo, Angola, and Benguela, with Sierra Leone and Accra copals as medium kinds, and Niger copal as the poorest. At the suggestion of the Imperial Institute, careful enquiries have been made during the last few years in the various British West African Colonies as to the botanical origin of the copals produced there. The results leave little doubt that Sierra Leone copal is obtained from *Copaifera Guibourtiana*, Gold Coast or Accra copal from *Cyanothyrsus Ogea*, Harms, and Niger copal from *Daniella oblonga*. The exports of copal from the Gold Coast were valued at £2,216 and £5,134 in 1906 and 1907 respectively, and from Sierra Leone at £3,945 in 1906.

At present Sierra Leone copal is quoted at 6½*d*. to 1*s*. 11*d*. per lb., and Gold Coast copal at 51*s*. 6*d*. to 71*s*. 4*d*. per cwt.

The Dutch East Indian and Polynesian copals are entirely obtained from living trees, and chiefly from *Dammara orientalis*. Formerly the resin was practically all sent in the first instance to the Philippine Islands, and was exported thence as "Manila copal." In recent years that gathered in the Dutch East Indies has been diverted to Singapore and Dutch East Indian ports of shipment, and reaches European markets as "Macassar," "Pontianac," or Singapore copals. Manila copal especially is largely used in the United Kingdom and United States of America for making the cheaper qualities of copal varnish.

The copal of New Zealand and New Caledonia is better known in trade as Kauri copal, and is a fossil product derived originally from the Kauri pine *Dammara australis*. This is chiefly used in the United Kingdom and the United States for varnish making. Its value in this country ranges at present from £6 per ton for "dust" to £340 per ton for the best quality. The exports from New Zealand were valued at £579,888 in 1907, and the imports into the United Kingdom for the same year at £474,063. The production of this resin in New Caledonia is at present of no commercial importance.

The South American localities yielding copal are British Guiana, Brazil, Colombia, and Venezuela, where it is collected mainly from living trees of *Hymenoea Courbaril*, but is also found in the fossil form. The product is known in this market as "Demerara animi." Its present value in the United Kingdom is about £40 to £160 per ton.

The resins of this group examined at the Imperial Institute have been as follows:—

Copal Resin from the Gold Coast.

Three samples of copal resin from Ashanti were forwarded to the Imperial Institute by the Superintendent of Agriculture for the West African Colonies and Protectorate in 1906.

Description of Samples.

No. 1, labelled "Dead tree copal, Obassi, Ashanti," consisted of a single cake of resin weighing about 3 lb. The cake was dark coloured externally, but the bulk of the resin had a yellow colour, thin sections being almost colourless and quite transparent. The resin had a slight aromatic odour, but no taste; it exhibited a conchoidal fracture, and was readily powdered.

No. 2, labelled "Copal from Eikona, Ashanti, said to occur plentifully, but no demand for it in Kumassi," weighed about 1½ lb., and consisted of two varieties of resin, which differed considerably in appearance.

(*a*) was a clear, light yellow resin of similar character to No. 1 from Obassi; it was quite transparent and devoid of taste.

(*b*) was translucent, of light buff colour, and possessed a slight odour; occasional white opalescent patches occurred throughout the lump. Both portions were free from enclosed foreign matter.

No. 3, labelled "Copal from Oboamang, Ashanti, said to occur in some quantity in the forests, but not saleable in Kumassi," consisted of several lumps of resin, which together weighed about 1 lb. The lumps varied in appearance, the majority being made up of several masses of clear or cloudy yellow resin interspersed with thin layers of foreign matter. Some of the outer cavities of the lumps were partly filled with a resin of much brighter yellow colour than the general mass.

One large lump included in this sample was much superior in quality to the remainder, being light yellow, translucent, and free from enclosed foreign matter.

Results of Examination.

The results obtained in the chemical examination of the three samples are in general agreement with the figures previously recorded for Gold Coast copal, and are given in the following table:—

	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Ash	2·21	0·12	0·5
Acid number ...	134	133	126
Melting point ...	145° C.	120° C.	128° C.

The resins were only partially soluble in alcohol, benzene, carbon disulphide, chloroform, ether, or turpentine oil, but were completely dissolved by mixtures of benzene and alcohol, turpentine oil and alcohol, or benzene and ether.

Commercial Valuation.

The resins were submitted to brokers for commercial valuation, and the following quotations were obtained:—No. 1, 60*s.* per cwt.; No. 2, 50*s.* per cwt.; No. 3, 30*s.* per cwt. (November, 1906).

Sample No. 1 was also sent to a firm of manufacturers, who valued it at a much lower price than the brokers, viz., 45*s.* to 47*s.* 6*d.* per cwt. It was stated that consignments similar to these samples could be sold without difficulty, as there is a good demand for copals of this class.

The manufacturers pointed out that moderate quantities of copal from the Gold Coast were formerly received in this country, but, owing to the diminution of the supplies, varnish makers turned their attention to other varieties, which can be regularly obtained in large quantities. Accra copal, the name by which the Gold Coast resin is known in the market, has so far never been held in very high favour, in consequence, it is thought, of the unsatisfactory way in which it has been shipped. The resin is usually sent in the rough state, with a large quantity of dust and dirt mixed with it, no attempt being made to separate the different qualities. Its value is thus considerably diminished.

On the other hand, Congo copals, which are now largely used, are more or less graded for colour and sometimes for size. In addition, the dust and dirt are carefully removed, and many of the consignments are roughly washed. As a result of this treatment some of the clean sorted Congo copals realise from £120 to £150 per ton.

There appears to be no reason why Gold Coast copal, if carefully cleaned and graded before shipment, should not realise satisfactory prices in the market.

In grading, the copal should be separated according to size and colour. The highest prices are obtained for pale, translucent resin in large and uniform pieces; the darker, or cloudy, pieces realise less, whilst the chips and dust fetch the lowest prices. The most important point is to secure uniformity in shipments, so that manufacturers can be sure that successive consignments of the resin, if treated in the same way, will yield a similar product.

The copal would realise a higher price if it were "washed" before shipment. This is usually done by scraping off the outer covering of dirt, dipping the scraped resin into a dilute alkaline solution, then into clean water, and finally drying.

A further sample of copal resin from Ashanti was forwarded by the Superintendent of Agriculture for the West African Colonies and Protectorates for examination and valuation in 1907.

It weighed 650 grams, and was mostly in the form of yellowish-white, flattened tears, showing a glassy fracture when broken. In addition to the tears there were a few larger, irregularly shaped pieces which were not quite so clean.

The resin was transparent when scraped free from a thin, opaque layer which covered the surface. It was only sparingly soluble in turpentine oil or chloroform, but dissolved to the extent of about 75 per cent. in alcohol. Mixtures of equal parts of alcohol and benzene, and of alcohol and turpentine oil, dissolved practically the whole of the resin. In benzene the

material was almost insoluble, and in a mixture of ether and benzene it swelled up and was not completely soluble.

On chemical examination the copal furnished the following results, which are in general agreement with those obtained with the samples of Accra copal already described, though the present sample is rather harder as shown by its higher melting point:—

	Present Sample.	Previous Samples. 1	2	3
Ash, per cent. ...	0·1	2·21	0·12	0·5
Acid number* ...	124	134	133	126
Melting point ...	180° C. ...	145° C.	120° C.	128° C.

The price of Accra copal ranges from 34*s*. 6*d*. to 72*s*. per cwt. (January, 1908) at the present time, and resin similar to this sample would probably realise the highest price if it were cleaned and the dirty pieces picked out before shipment.

Two samples of copal resin from the Sekondi District of the Gold Coast were received for examination in 1908.

Description.

No. 1 consisted of a fairly clear mass, light-brown in colour with no weathered crust. It weighed 83 grams.

No. 2 was a very rough, irregularly shaped, opaque mass, covered with a thin weathered crust and contained a small amount of woody matter. When fractured this sample was found to contain an appreciable amount of water. It weighed 158 grams.

Results of Examination.

A chemical examination of the powdered air-dried resins gave the following results:—

	No. 1.	No. 2.
Moisture	Slight gain in weight at 100° C	4·6 per cent.
Ash ...	... 0·2 per cent.	0·2 „ „
Acidity*	... 133	133

The melting point of both samples was from 140° to 150° C.
The solubilities of the resins were as follows:—

Solvent.	No. 1.	No. 2.
Chloroform	partially soluble; swells up.	partially soluble; swells up.
Alcohol	almost completely soluble.	not quite so soluble as No. 1.
Ether	almost completely soluble.	not quite so soluble as No. 1.

* Milligrams of potash (KHO) required per gram of resin.

Solvent.	No. 1.	No. 2.
Turpentine oil.	sparingly soluble.	sparingly soluble.
Turpentine oil and benzene.	" "	" "
Turpentine oil and alcohol.	completely soluble.	completely soluble.
Benzene ...	sparingly soluble.	sparingly soluble.

The loss of weight on "cleaning" sample No. 2 with alkaline liquids amounted to 20 per cent.

Commercial Valuation.

Samples of the resins were submitted to experts for commercial valuation.

No. 1 was reported to be a very good copal which would meet with a ready sale. If bulk consignments picked equal to this sample could be obtained they would be worth about 70*s*. per cwt., and even if mixed with small pieces the value would be from 40*s*. to 45*s*. per cwt.

No. 2 was reported to be of poor quality and only worth from 27*s*. 6*d*. to 30*s*. per cwt. (May, 1908).

SIERRA LEONE COPAL.

Two small supplies of this copal were received from Sierra Leone in 1906. It was stated that the samples represented two grades, and it was desired to ascertain the quality and value of each, and also for comparison the value of the material if ungraded.

Description.

Sample No. 1, labelled "Copal, 1st grade," consisted of about 1½ lb. of the resin in tear-shaped lumps. It possessed a slight aromatic odour. The majority of the pieces were transparent and of a light-yellow colour, though occasional pieces of cloudy resin were also present; the tears were fairly free from enclosed foreign matter.

Sample No. 2, labelled "Gum Copal, 2nd grade," consisted of about ½ lb. of the resin. The tears were smaller than those of No. 1 and contained more foreign matter, chiefly of a vegetable nature, enclosed in the lumps. No. 2 also included several pieces (about 2 oz.) of a resin which appears to be quite distinct from ordinary Sierra Leone copal. The pieces were not homogeneous in colour but varied from dirty-white to reddish-brown. When ground the material possessed a peculiar aromatic odour, quite different from that of the rest of the sample.

Results of Examination.

The samples were submitted to chemical examination and gave the following results, which agree generally with the figures recorded for Sierra Leone copal:—

	No. 1.		No. 2.		Foreign resin present in No. 2.
Ash, per cent. ...	0·04	...	0·20	...	0·59
Acid number ...	127	...	127	...	102
Melting point ...	137° C.	...	125° C.	...	145° C.

Both samples were partly soluble in alcohol, ether, chloroform, carbon disulphide or turpentine oil, and were completely dissolved by a mixture of alcohol and benzene.

The foreign resin present in sample No. 2 gave slightly different results on chemical examination, and was not entirely soluble in any mixture of solvents tried.

Commercial Valuation.

A commercial firm, to whom the samples were sent for valuation, reported that No. 1 was worth about 2*s*. 2*d*. per lb., and No. 2 (without separating the foreign resin) 1*s*. 9*d*. per lb. They stated that there is a good demand for such copal, and recommended shipments.

A second valuation was obtained from another firm who described sample No. 1 as very fine, clear copal, which would be worth 2*s*. 6*d*. per lb. In the case of No. 2 they separated the unknown material and valued the remainder at 1*s*. 11*d*. per lb. This firm also stated that the value of the two samples mixed together in about equal quantities would be about 2*s*. 2*d*. per lb. (October, 1906).

COPAL FROM SOUTHERN NIGERIA.

Some interest attaches to this product which has been placed on the market in considerable quantities in recent years. According to the Conservator of Forests for Southern Nigeria it is derived from *Cyanothyrsus ogea*, Harms. (*Daniella oblonga*, Oliv.), and appears to be identical with "Ogea gum" of which small consignments formerly reached this country from time to time from West Africa.

A small sample of "Ogea gum" collected at Olokomeji in 1907 was received at the Imperial Institute from the Superintendent of Agriculture for the West African Colonies and Protectorates, and the opportunity has been taken to compare this with Nigerian copal of commerce. The "Ogea gum" was in small fragments of yellow, glassy resin, whilst the commercial sample of Nigerian copal, which was obtained in 1902, consisted of a single mass of glassy, pale-yellow resin, possessing a faint terebinthinous odour when freshly broken. Both samples were

submitted to a preliminary examination and gave the following results:—

	Nigerian copal.	"Ogea gum."
Ash, per cent. ...	0·0	0·5
Acid number ...	110	116
Melting point ...	180° C. (approx.)	120° C. (approx.)

Solubility:

	Nigerian copal.	"Ogea gum."	
Completely in.	Mixture of alcohol and benzene. Mixture of ether and benzene.	Mixture of alcohol and benzene. Mixture of alcohol and turpentine oil.	Completely in.
Partially in.	Chloroform Turpentine oil.	Turpentine oil Alcohol.	Partially in.
Almost insoluble in.	Alcohol.	——	

On comparing these results it will be seen that there is a general resemblance in the properties of the two resins and the differences noted, particularly the fact that the Nigerian copal is *nearly insoluble* in alcohol, whilst the "Ogea gum" is *partially* dissolved by that solvent, and that the former melts at a much higher temperature than the latter, are perhaps to be accounted for by the greater age of the first sample, which as already indicated was obtained in 1902, since it is well known that resins of this type become less fusible and less readily soluble with age. The present value of Nigerian copal is about 35*s*. per cwt. (October, 1908).

RESIN OF *Daniella Thurifera* FROM NORTHERN NIGERIA.

It has been stated frequently that *Daniella thurifera* is the source of the so-called West African or Illorin "balsam of copaiba" or "wood oil," of which considerable quantities have been imported in recent years into Europe, and which is commonly used by natives in West Africa as a substitute for true "balsam of copaiba." The statement has also been made that a copal is collected from the same tree.

The Superintendent of Agriculture for the West African Colonies and Protectorates paid some attention to this point during a recent tour in Northern Nigeria, and collected small samples of the oil and resin, and a herbarium specimen. These samples were forwarded to the Imperial Institute for examination. The herbarium specimen was submitted for identification to the Royal Gardens, Kew, where Dr. Stapf confirmed the view that the tree is *Daniella thurifera*, Oliv.

The other samples received were as follows:—

No. 18. "Gum (copal?) exuded from the bark of *Daniella thurifera.*"

This weighed 1·3 oz., and consisted of small, translucent yellowish fragments with some vegetable *débris*. The resin had a slight odour recalling that of mastic.

No. 19. "Tube containing remains of tapping wood oil from the same tree."

The contents of the tube consisted of a semi-solid, almost black, sticky mass, with a terebinthinous odour. It weighed about 0·25 oz. and was too small for examination.

No. 20. "Tube containing naturally exuded gum (copal?) from same tree."

This weighed about 0·12 oz. and consisted of small yellowish-brown granular fragments.

Samples 18 and 20 were submitted to a general examination and gave the following results:—

	No. 18.	No. 20.
Ash	Trace	1·2 per cent.
Acid number	97	132.
Melting point	90° C. (approx.)	90° C. (approx.)
Solubility.	Completely soluble in turpentine-oil and mixture of alcohol and turpentine oil. Almost completely soluble in alcohol: mixture of alcohol and benzene.	Completely soluble in alcohol; mixture of alcohol and benzene; turpentine oil.

These results are of interest as showing that these two resins are different from Accra copal and the typical copals of commerce in melting at comparatively low temperatures and in being readily and practically completely soluble in the crude state in single organic solvents, such as alcohol or turpentine oil.

It seems likely that both these products are formed by the natural exudation of the "balsam" (oleo-resin), which then dries to resin on exposure to the air. It is, of course, possible that such resin on long exposure to air and moisture (fossil or semi-fossil resin) might yield a product which could be employed as a copal, but these samples do not closely resemble in properties the various freshly-exuded resins which come on the market under the name of "recent" or "soft" copals.

A further sample of the resin of *Daniella thurifera* was received from Northern Nigeria in June, 1908.

It was labelled: "Obtained from the ground round the root of the tree *Daniella thurifera?*" The sample weighed about 600 grams, and consisted of a mixture of amber-coloured and yellowish-brown fragments, most of which were small. Some pieces were clean and almost transparent, whilst others contained a considerable amount of foreign matter. The clean fragments only were used in the examination, and gave the following results:—

Ash	0·35 per cent.
Melting point	110° to 115° C.
Acid number	105.

The resin was almost completely soluble in turpentine oil, and in mixtures of turpentine oil with benzene or alcohol.

The results of the examination agree fairly well with those obtained for the previous sample (see above), and confirm the

opinion already expressed that this resin does not resemble the copals of commerce. A firm of varnish-makers, who were consulted on this matter, agree with this view, and state that soft resin such as this is not of much use for their purposes, and is commercially of little value (May, 1909).

RESIN OF *Daniella Thurifera* FROM THE GAMBIA.

A sample of this resin was also collected in the Gambia by the Inspector of Agriculture for West Africa early in 1909 and sent to the Imperial Institute for examination.

It was labelled: "Incense resin from *Daniella thurifera*, Gambia." The sample weighed about 150 grams, and consisted chiefly of dark-brown, somewhat sticky masses of resin adhering to pieces of bark, together with a few clear, amber-coloured, brittle tears. Only the latter were employed for chemical examination, and this gave the following results:—

Ash	0·32 per cent.
Melting point	110° to 115° C.
Acid number	109.

The resin was partially soluble in chloroform, in turpentine oil, in benzene, and in a mixture of turpentine oil and benzene, and was completely soluble in a mixture of turpentine oil and alcohol.

The above results agree fairly well except as regards solubility in single solvents with those obtained previously for samples of the resin of *D. thurifera*, and show that the product is of little commercial value and not likely to be saleable in this country. This view was supported by a firm of varnish-makers to whom a sample was submitted. They reported that the resin contained a large percentage of useless, rough matter (May, 1909), and that it would not be of much value for their purposes.

There would be no demand for this material in Europe as an incense resin, as the aroma produced on burning is inferior to that obtained from olibanum and the other more aromatic resins at present in use for this purpose.

The Inspector of Agriculture states that the "wood oil" of *D. thurifera* does not appear to be known in the Gambia. This is probably because the tree is not tapped for the purpose, as no doubt the "incense resin" is produced by the gradual drying of the wood oil, which exudes from natural cracks and fissures in the trees.

Dammara vitiensis RESIN FROM FIJI.

The resin dealt with in this report was shown in the Fiji Court at the Franco-British Exhibition in 1908, and was afterwards transferred to the Imperial Institute, at the request of the Government of Fiji, in order that it might be examined and its nature and value determined.

Description of Sample.

It consisted of a large mass of yellowish-brown resin, opaque throughout, with occasional streaks of opalescent material. The resin had a slight odour of turpentine oil, and contained, here and there throughout the mass, small pieces of reddish-coloured bark.

Results of Examination.

The resin furnished the following results on examination:—

Ash	0·06 per cent.
Melting point*	110° to 115° C.
Acid value	157.

The resin was partially soluble in turpentine oil or benzene and completely soluble in a mixture of turpentine oil and alcohol, but was almost insoluble in ether, chloroform or alcohol.

The foregoing results are of interest as showing that this resin somewhat resembles Manila and Macassar copals, especially in its range of solubility. Manila copal is stated to be derived from *Dammara orientalis* (*Agathis loranthifolia*), of which *D. vitiensis* (*A. vitiensis*), the source of the present sample, is a near relative.

Commercial Valuation.

A sample of the resin was submitted to a firm of varnish-makers who reported that it partly resembled Manila copal, and that its commercial value when scraped and cleaned would be from 30*s*. to 35*s*. per cwt., unless the bulk of the resin obtainable differed in colour from the sample (May, 1909).

It is essential that resin such as the present sample should be carefully prepared before shipment. Copal resins are usually broken up, cleaned and graded before export, unless, like Sierra Leone copal, they are obtained naturally in clean "tears." In the case of this Fiji copal the masses should be broken up into roughly cubical pieces of about 1 inch to 1½ inch side. Each piece should be examined, and any pieces of bark or other impurity removed and rejected. Similarly, any pieces of resin which differ markedly in colour should be removed and dealt with separately. The pieces of resin from the outside of the original mass should either be placed together and sold as a separate lot, or, if mixed with the rest, should first have the original external surface scraped so as to present a fresh, clean surface. Any "small" or "dust" resin formed in the process should be placed together and sold separately.

Supposed Kauri Resin from Queensland.

A sample of resin was forwarded to the Imperial Institute by the Agent-General for Queensland with the request that its commercial value might be ascertained. In the letter accompanying

* Determined on the powdered resin in a capillary tube.

the sample it was stated that the material was "thought to be a species of Kauri," and that it was obtainable in fair quantities in Queensland. The resin on examination gave the following results:—

The sample consisted of a single rounded block, weighing about three pounds, composed of a bright yellow transparent resin, with a number of dark streaks and opaque patches scattered throughout its mass. The material had a pleasant, aromatic odour, especially when freshly broken. It was almost completely soluble in alcohol and ether, slightly soluble in benzene, and very slightly so in chloroform.

The specific gravity of the resin was 1·0543, it furnished on ignition 0·13 per cent. of ash, and its acid number was 136·6.

These results indicated that the material was quite different from New Zealand Kauri resin, since the latter is only partially soluble in alcohol and ether, and in general has an acid number in the neighbourhood of 101.

No information regarding the botanical origin of the Queensland product was forwarded with the sample, but the similarity in the chemical properties of this material to those of the resin known commercially as "Australian sandarac" indicated that these two products might have a common origin. Australian sandarac occurs in commerce in the form of small light yellow tears, and is obtained from various species of *Callitris*, the most important of these being *Callitris calcarata* and *Callitris verrucosa*.

This similarity of the Queensland resin to Australian sandarac is shown by the following comparative statement of the principal constants of the two resins:—

	Specific gravity.	Acid Number.	Solubility.
Queensland resin	1·0543	136·6	Soluble in alcohol or ether.
Australian sandarac ...	1·060	135·8	" " "

The chemistry of the resin of *Callitris verrucosa* was made the subject of a special investigation by Dr. T. A. Henry in the Scientific and Technical Department of the Imperial Institute in 1901, the results of which were published in the "Journal of the Chemical Society," 1901, p. 1144, and this work has now been repeated on the Queensland resin. The quantity of the latter sent for examination was too small to permit of an exhaustive investigation of its constituents, but conclusive evidence has been obtained that, like the resin of *Callitris verrucosa*, it consists essentially of pimaric and callitrolic acids. It may, therefore, be assumed provisionally that the Queensland resin is derived from a species of *Callitris*, and that it may be regarded as a sandarac.

Commercial Valuation.

Sandarac resin is principally employed in the manufacture of varnishes. For this purpose African sandarac obtained from

Callitris quadrivalvis is regarded as the best of the commercial varieties, and is worth from 60*s*. to 70*s*. per cwt. Australian sandarac, which is stated to be principally obtained from New South Wales, occasionally appears on the English market, and recently, owing to a scarcity of the African product, has been in slight demand at about 35*s*. per cwt.

The African and Australian sandaracs so far met with in commerce occur in characteristic, elongated, light yellow "tears" quite different in appearance from the large block form in which the Queensland resin was sent. The latter, owing to its unusual form, would probably not be saleable at quite so high a price as the ordinary "tear" form of Australian sandarac, and at first it is unlikely that more than 25*s*. to 30*s*. per cwt. could be obtained for it.

It may be pointed out that there is practically no difference in composition between the Australian and African sandarac resins, and that the lower prices obtained for the former are to be ascribed principally to the irregularity and deficiency of the supply from Australia and the consequent want of knowledge of this product among manufacturers using sandarac in this country (March, 1904).

DAMMAR.

The dammars form a group of resins characterised by being largely soluble in spirits of wine or oil of turpentine and therefore suitable for the preparation of so-called "spirit varnishes" used mainly for indoor woodwork, paper, cloth, &c. They are obtained from species of *Hopea*, *Shorea*, and *Balanocarpus*, mainly in the Federated Malay States, as well as in Sumatra and other Dutch East Indian Islands. Small quantities of dammar-like resins are obtained in India, but so far as European commerce is concerned these are of no importance. The dammars are all collected from living trees. The Dutch East Indian resin is shipped chiefly from Batavia, whilst the product of the Federated Malay States reaches Europe viâ Singapore.

The value of Singapore dammar in London at present is 25*s*. to 67*s*. per cwt., whilst that from Batavia is worth 65*s*. to 70*s*. per cwt.

Dammar Resins from the Federated Malay States.

These dammar resins, produced in the Federated Malay States, were forwarded to the Imperial Institute by the Conservator of Forests in 1905, with the request that information might be supplied as regards their suitability for varnish-making and their probable commercial values in this country.

Description of Samples.

No. 1 (*Dammar Penak*, No. 1 quality, derived from *Balanocarpus* [*Maximus* or *Wrayi*]).—The sample weighed nearly one pound, and consisted of tears agglomerated into masses of light-yellow transparent resin. It was brittle, readily reduced to

powder, and appeared to be quite free from any foreign matter. It was partly soluble in alcohol, completely so in ether, and almost entirely soluble in turpentine, forming a slightly opalescent solution, which when applied to sized wood dried to a brilliant, transparent, hard, and almost colourless " coat."

No. 2 (*Dammar Kumus*, from a Shorea sp., rather like *Shorea glauca*).—The sample weighed about four ounces, and consisted of two small masses of reddish-brown resin, which was translucent in thin pieces. It was partially soluble in alcohol, and almost completely soluble in ether. The solution in oil of turpentine was dark coloured, and when applied to sized wood left a fairly hard, brownish " coat " which was not very glossy.

No. 3 (*Dammar Mata Kuching* [Port Dickson]).—This sample weighed about 1·5 ounces, and consisted of small, roughly ovoid, slightly yellow transparent tears of resin. It was hard, and free from foreign matter, and dissolved partially in alcohol and completely in ether. The solution in oil of turpentine was clear, and when applied to sized wood left a hard, brilliant, nearly colourless " coat."

No. 4 (*Dammar Soongyi*).—This weighed nearly fourteen ounces, and consisted of irregularly shaped lumps of dark-brown resin, which was translucent in thin pieces. The resin was hard; it dissolved partially in alcohol or ether and completely in oil of turpentine, forming a brown, opaque solution which dried on wood, leaving a light brown, soft, dull " coat."

No. 5 (*Dammar Meranti*, derived from various *Shoreas*, of inferior quality).—This sample weighed about twenty ounces, and consisted of a single lump of opaque, yellowish-white resin, which was friable and softened readily when rolled between the fingers. It was partially soluble in alcohol or ether, and formed with oil of turpentine an opaque varnish which when applied to wood left a dull and sticky " coat."

No. 6 (*Dammar Mata Kuching from Jempol*).—The sample consisted of a lump of hard, transparent, pale amber-coloured resin, weighing about seven ounces. It was free from foreign matter and was partially soluble in alcohol and completely soluble in ether. It dissolved in oil of turpentine to form a pale yellow transparent solution, which dried on sized wood, forming a hard, brilliant, and almost colourless varnish similar to that produced by Sample No. 1.

No. 7 (*Dammar Rengkong?*).—This weighed about two ounces, and consisted of small pale yellow, hard and transparent tears. It was partially soluble in alcohol or ether and dissolved completely in oil of turpentine, forming an opalescent solution, which dried on sized wood leaving a " coat " which was hard, but lacked gloss.

No. 8 (*Dammar Merawan from a Shorea*).—The sample weighed nearly two ounces, and consisted of large translucent, yellowish-white tears of resin. It was partially soluble in alcohol, completely so in ether, and formed an almost colourless solution in turpentine oil, and this on drying left a fairly hard, clear, glossy " coat " inferior to those produced by Nos. 1, 3, and 6.

No. 9 (*Dammar Strayah*).—This weighed about five ounces, and consisted of lumps of pale yellowish-brown resin showing a laminated structure. It was partially soluble in alcohol or ether. The solution in oil of turpentine dried to a fairly hard "coat," which was devoid of gloss.

Chemical Examination.

The nine samples of resin, when chemically examined, gave the results recorded in the following table:—

----	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.
Melting point	90°C	94°C	87°C	180°C	185°C	92°C	200°C	97°C	190°C
Ash, per cent.	0·26	0·08	0·05	0·52	0·03	0·06	0·04	0·25	0·09
Saponification number*	46·7	72·0	38·5	34·3	72·0	33·0	46·7	38·5	55·0
Acid number*	45·3	72·0	38·5	33·0	72·0	33·0	46·5	38·5	55·0
Ester number*	1·4	—	—	1·3	—	—	0·2	—	—

* Milligrams of potash required for one gram of resin.

The results of this examination show that these resins exhibit considerable differences in chemical composition and properties. They are all, however, partially soluble in alcohol and completely soluble in turpentine oil, forming fairly light-coloured varnishes, and would therefore be classed commercially as dammars.

Commercial Valuation.

Samples of the nine dammars were submitted for valuation to commercial experts, who were also informed of the results of their examination. They reported on the samples as follows:—

Number of sample.	Description.	Commercial experts' comment.	Commercial values estimated by experts.
No. 1 ...	Dammar Penak.	"Clean pale yellow"	55s. to 60s. per cwt.
" 2 ...	" Kumus.	"Black"	20s. per cwt.
" 3 ...	" Mata Kuching (Port Dickson)	"Pale drop"	70s. "
" 4 ...	" Soongyi.	"Black"	15s. "
" 5 ...	" Meranti.	"Chalky"	10s. "
" 6 ...	" Mata Kuching (Jempol)	"Bold pale"	60s. "
" 7 ...	" Rengkong.	"Green, like Ceylon"	35s. "
" 8 ...	" Merawan.	"White"	35s. "
" 9 ...	" Strayah.	"Chalky inferior"	5s. to 6s. per cwt.

The prices quoted for the better qualities of the dammars included in this series of samples compare very favourably with those obtained in the open market in London, thus on the 11th November, 1905, the better qualities of Batavian dammar were quoted at from 70s. to 80s. per cwt. and Singapore kinds at from 30s. to 75s. per cwt. (November, 1905).

"Black" Dammar Resin from Assam.

A small consignment of this resin, derived from *Canarium bengalense*, was forwarded to the Imperial Institute in 1903 by the Officiating Reporter on Economic Products to the Government of India, with the information that it had been collected in Cachar, Assam, and asking for a report on its chemical characteristics and its commercial value, and for some information as to the possibility of creating an export trade in this product.

Chemical Examination.

The resin was chemically examined, and gave the results recorded below:—

The sample consisted of large flattened pieces of resin, usually with small portions of bark adhering to its surface. It was of a dull dark-brown colour, showed a glassy, conchoidal fracture, dissolved readily and completely in oil of turpentine and in benzene, chloroform or acetic anhydride, but was only partially soluble in alcohol or ether.

The resin melted at 125° C., and yielded on ignition 0·78 per cent. of mineral ash. Its saponification value was 9·43, acid value 8·15, and ester value 1·28. When a drop of concentrated sulphuric acid was added to a solution of the resin in acetic anhydride a deep purple coloration was produced; the addition of sulphuric acid to a solution of the resin in chloroform gave a yellow coloration, which slowly changed to ruby red.

The results indicate that the resin is of the dammar type, although it differs to some extent from the black dammar of commerce stated to be derived from *Canarium strictum*, especially in possessing lower acid and saponification values.

Commercial Valuation.

Specimens of the resin were submitted to varnish manufacturers for technical trial, and to commercial experts for valuation, together with a statement of the analytical results given above. The varnish-makers reported that the resin was suitable for the preparation of hard drying varnish, such as is required in the manufacture of enamel paints. The dark colour would, however, to some extent prejudice its sale, and it is unlikely that a higher price than 18*s*. per cwt. could be obtained for it (April, 1904).

The possibility of creating an export trade in this product will depend upon whether the price quoted will prove remunerative to exporters in India, and also upon whether a regular supply of the resin can be maintained.

"Rock" Dammar from Burma.

A sample of this resin was forwarded to the Imperial Institute by the Reporter on Economic Products to the Government of India in 1903, in order that it might be chemically examined and its commercial value ascertained. The resin is stated to be known in Indian commerce as "Rock Dammar," and to be

especially abundant in the South Tenasserim Division of Burma, where it is procurable at the rate of 4 annas per viss, approximately equivalent to 10*s*. per cwt. It is derived from *Hopea odorata*.

The specimen consisted of large, irregularly-shaped tears of a yellow colour, possessing a brilliant, irregular fracture, and a slight aromatic odour. The resin melted at 115° C., and yielded 0·56 per cent. of ash. Its saponification value was 37·1, acid value 31·5, and ester value 5·6. It was completely soluble in turpentine oil and partially so in alcohol.

These results indicate that this resin may be regarded as a dammar resin, and may be classed with the better varieties. A sample of this product was submitted to a firm of varnish makers for technical trial and commercial valuation. They reported that the resin would be classed commercially as a second quality dammar, and that it could be used for the preparation of "paper" or "crystal" varnishes such as are employed for indoor decorative work. Its value at present would be about £2 5*s*. per cwt. (January, 1904). The demand for resins of this type is unfortunately somewhat limited, since varnishes made with them are not sufficiently durable to be used for outdoor work. The varnish makers, however, point out that if this resin could be procured in a "fossilised" form it would probably yield a varnish as durable as that obtained from Manila copal, and that, although the price obtainable for the "fossilised" resin would be somewhat less than that quoted, the demand would be practically unlimited.

A further sample of Rock Dammar, collected by the Officiating Conservator of Forests, Tenasserim, Rangoon, was forwarded for examination to the Imperial Institute by the Officiating Reporter on Economic Products in August, 1905.

This sample had been collected from the ground near "rock dammar" trees in the hope that it would exhibit the more durable qualities of a "fossilised" resin referred to in the previous report (*see* above).

Description of Sample.

It weighed 2½ pounds, and consisted of (1) a few large pieces of pale yellow resin containing much earthy matter and having pieces of bark adhering to them; (2) small lumps of light yellow resin, which were fairly free from earthy matter and debris; (3) small fragments of transparent or translucent resin mixed with earthy fragments of bark, twigs, &c.

The resin was brittle, but much of it softened readily when rolled between the fingers, and the clean fragments broke with a conchoidal fracture. It had a slight characteristic odour.

Results of Examination.

The sample of resin as received contained so much foreign matter that it was considered advisable to select from it some of the cleaner pieces for examination, since an analysis of the

crude product would afford no indication of the real nature of the resin. The results obtained are given in the following table, to which have been added for comparison the figures relating to the previous sample (*see above*):—

	Clean yellow resin, selected from present sample.	Resin examined in 1904.
	per cent.	per cent.
Ash	0·68 ...	0·55
Saponification number ...	31* ...	37·1*
Acid number	31† ...	31·5†
Ester number	0·0 ...	5·6
Melting point	90° C. ...	115° C.
Specific gravity	0·980 to 1·013	

The clean resin was completely soluble in turpentine oil, chloroform, or acetic anhydride, and soluble to a small extent in 90 per cent. alcohol.

Conclusions.

The results of the examination show that the present crude sample of *Hopea odorata* resin is much inferior in quality to that previously examined since it contains so much earthy and vegetable impurity. The melting point of the clean resin selected from the crude sample is also lower than that of the earlier specimen, and this fact seems to indicate that it is a fresher sample merely impregnated with dirt and other impurities through having fallen on the ground. It is doubtful, therefore, whether the present sample can be regarded as representative of the "fossilised" resin of *Hopea odorata*. The true "fossilised" resin would probably have a higher melting point and be only partially soluble in single solvents such as turpentine oil.

A consignment of this resin similar to the present sample as received would fetch comparatively little in the market, as, owing to the large amount of impurity associated with it, the resin would require sorting before it could be used. The *clean* resin could, however, be utilised for the same purposes as the specimen previously reported on, but on account of its softer character it would probably realise a slightly lower price. (May, 1906.)

NATURAL VARNISH.

The best known product of this type is that obtained from the varnish tree of China and Japan, *Rhus vernicifera*, by incision of the bark. This product is used in the two countries mentioned for the decoration of wood and iron articles, which are then known as "lacquer wares." A similar but less known

* *Milligrams of caustic potash required to saponify* 1 *gram of resin.*

† *Milligrams of caustic potash required to neutralise the free acid in* 1 *gram of resin.*

natural varnish is collected in Burma from the plant known as *Melanorrhœa usitata*.

These products, as obtained from their respective trees, are nearly colourless viscous liquids, which on exposure in thin films to a moist atmosphere dry to hard black lustrous varnishes. They are mainly used in their countries of origin, though a few years ago an export of " Japanese lacquer " was arranged for by a syndicate having its headquarters in Germany.

The *Garcinia* resin described below presents some features in common with those of the natural lacquers just referred to, but further investigation is required before it can be definitely asserted to be of the same type.

GARCINIA RESIN FROM PERAK, FEDERATED MALAY STATES.

This material was forwarded to the Imperial Institute on behalf of the Government of the Federated Malay States by Mr. Leonard Wray, Curator of the Perak Museum, in 1904. The specimen was accompanied by a letter giving the following information with regard to the extraction and preparation of the resin:—

" The resinous substance is the dried sap of a *Garcinia*. The sap is obtained by making incisions in the bark of the trees. It is then boiled until it is as thick as cream, when a little turpentine is added, and it is ready for use as varnish, being applied to the wood by means of a pad of cloth.

" As prepared it is an emulsion of a pale yellow colour; if boiled till all the water is evaporated it solidifies, and cannot be dissolved again with turpentine, but if water is added at once it may again be made into an emulsion. It will only keep in good condition for a few days, fermentation of the watery portion of the sap readily setting in.

" This Malay varnish is, when dry, nearly white, very hard and brilliant, being quite equal to the Japanese lacquer. The tree which yields it is a wild one, and as it fruits freely there should be no difficulty in planting it."

Chemical Examination.

The sample weighed about 4 ounces, and consisted of a semi-solid resin contained in a portion of a bamboo stem. Internally the material was soft and opaque, and had a pale yellowish colour, and an odour resembling that of " t'ung " oil, but externally it was dark-brown in colour, and was covered by a very thin layer of brittle material, probably produced by the action of the atmosphere on the resin. This hard outer layer, which is probably identical with the insoluble resin produced by evaporating the whole of the water from the sap, constituted only a minute proportion of the whole; it was insoluble in turpentine oil and the usual solvents, but the small amount obtainable precluded its further investigation.

The resin, when freed from the thin outer layer of altered material, was soluble in turpentine oil, chloroform, benzene, and

ether, and almost completely so in alcohol. It melted at 65° C. (159° F.), and on ignition furnished 0·21 per cent. of ash. One gram of the resin required 89·2 milligrams of potassium hydroxide for neutralisation, and 93·5 milligrams of this re-agent for complete saponification. It contains, therefore, a large proportion of free resin acids, and a comparatively small amount of resin esters.

When dissolved in turpentine oil, and the solution applied as a varnish to wood, there was left on drying a hard almost white "coat," similar to that produced by dammar varnishes.

A small sample of the resin was submitted to a firm of varnish makers for technical trial; they reported that it could probably be used as a substitute for dammar resin in the preparation of varnishes suitable for indoor work, but that it would be necessary to carry out experiments on a large scale before a definite commercial value could be assigned to the material.

It is desirable that steps should be taken to identify the particular species of *Garcinia* from which this resin is derived. In this connection it is of particular interest to note that this resin appears to be quite different in constitution from the gum-resin, gamboge, obtained from the nearly allied plants *Garcinia Hanburii* and *Garcinia morella*. (July, 1904.)

ELEMI RESINS.

The name "elemi" is in commerce practically restricted to the soft, aromatic oleo-resin collected in the Philippine Islands, from a species of Canarium, but from time to time small quantities of similar resins from other localities come on the market and are sold as "elemi," usually with the addition of a qualifying adjective to the name, which indicates the country of origin, and serves to distinguish them from the product of the Philippines. Thus the oleo-resin of *Dacroydes hexandra* is known as "West Indian" or "dry elemi" in this country, though in the West Indies it is better known as "gommier resin." Similarly from various parts of West Africa, such as Liberia, Cameroons, Southern Nigeria, and elsewhere, small quantities of an aromatic oleo-resin are received from time to time under the name of "West African elemi."

Until quite recently the botanical origin of the true elemi of commerce was not known with certainty, but as the result of an investigation carried out by officials of the Bureau of Science, established in the Philippines since these islands were annexed by the United States of America, it is now known that the oleo-resin is collected from *Canarium luzonicum* (Clover, *Phil. Journ. Sci.*, 1907, 2, 2). The fresh oleo-resin contains from 25 to 30 per cent. of volatile oil composed mainly of hydrocarbons of which phellandrene forms by far the largest proportion. The non-volatile residue is of the nature of a resin, but, unlike these products in general, it is largely composed of

readily crystallisable matter which can be separated into two well-defined substances, distinguished as *α*-amyrin and *β*-amyrin respectively.

At one time elemi was used in considerable quantities in medicine, as an ingredient in ointments and plasters, but this use has almost ceased, and at present it is mainly employed in the preparation of printing inks, and occasionally as an ingredient in varnishes. The small demand which exists for elemi appears to be readily met by the supplies obtainable from the Philippines. At present good Manila elemi is worth from 40*s*. to 50*s*. per cwt. (May, 1909.)

GOMMIER RESIN FROM DOMINICA.

This consignment of gommier resin was forwarded by the Administrator of Dominica, in 1903, to Dr. F. Watts, Government Analytical Chemist for the Leeward Islands, who was then in England, in order that the commercial value of the material might be ascertained. At Dr. Watts' suggestion the matter was referred by the Colonial Office to the Imperial Institute for investigation.

In the correspondence accompanying the sample it was stated that the gommier tree, *Bursera gummifera* (?) (*see next page*), is of common occurrence in the forests of Dominica, and that the resin is collected by the natives and used locally for the preparation of torches and as incense. The resin exudes either from natural fissures or from cuts made in the bark; it is at first an opaque, whitish, highly viscous liquid, which soon dries into soft yellowish lumps, and eventually into hard, brittle masses of white resin, and it is in the latter form that it is usually collected. The cost of collecting the resin in Dominica is stated to be from 3*d*. to 4*d*. per lb.

Small consignments of the material have been sold in European markets from time to time, principally as a substitute for Manila elemi. On account of its general resemblance to true elemi, gommier resin is commonly known as "dry," or West Indian elemi.

The present consignment of gommier resin consisted principally of large flattened lumps of hard resin, somewhat dirty externally, but snow white internally. When examined under the microscope these lumps were found to consist almost entirely of a substance crystallising in minute needles. There was also present a small proportion of lumps of soft resin which was slightly yellow, and generally contaminated by pieces of bark, earth, small stones, &c. This soft resin was crystalline only on the surface.

The material had a pleasant aromatic odour, which was especially marked in freshly broken pieces of the softer resin.

Chemical Analysis of the Gommier Resin.

As the hard and soft resin differed materially in composition, representative specimens of each kind were selected for analysis.

The results of this investigation are tabulated below, the corresponding figures for commercial specimens of elemi resin being added for comparison:—

	Gommier Resin.		*Elemi Resin.*
	Hard.	Soft.	
Saponification value ...	24·7	41·6	25·72 -49·98
Acid value	14·1	37·3	17·7 -24·48
Ester value	10·6	4·3	7·64 -26·99
	Per cent.	Per cent.	Per cent.
Ash	0·08	0·36	0·023- 0·93
Melting point ...	158°-164°	Below 100°C.	—

The hard resin is completely soluble in alcohol, and partially so in turpentine oil, whilst the soft resin is entirely soluble in turpentine oil and only partially so in alcohol.

These results indicate that the West Indian resin is probably similar to true elemi in composition, but the exact differences between the two products could only be ascertained by a complete chemical investigation of the constituents of the two resins. Preliminary experiments have shown that the principal constituent of the gommier resin is a white crystalline substance probably identical with one of the constituents of elemi resin.

Commercial Valuation.

The principal purposes to which elemi resin is applied are the preparation of printing inks and the manufacture of spirit varnishes, although a small quantity is also used in medicine. Specimens of gommier resin were submitted to manufacturers of printing inks and to varnish makers, who both reported that the soft gommier resin would answer their purposes as well as elemi. Other samples were then submitted to brokers for valuation. They stated that the material was somewhat dirty, and would only be worth from 17*s.* to 18*s.* per cwt., as compared with 50*s.* to 55*s.* per cwt. obtainable for true elemi. This difference in price is probably to be accounted for by the fact that elemi is usually sold in this country in a comparatively fresh and soft condition, and that it is generally fairly free from dirt. (January, 1904.)

It is probable that gommier resin, if exported in a fresh and clean condition, would realise prices more nearly equal to those obtained for true elemi.

A second supply of Gommier resin was sent to the Imperial Institute by the Acting Administrator of Dominica in May, 1904.

This material has been examined and compared with the previous sample, and has also been submitted to brokers for commercial valuation.

Botanical Origin of Gommier Resin.

Gommier resin is stated by various authors (Dieterich, Analyse der Harze, p. 123, Rea, Imperial Institute Journal, vol. viii.,

p. 240, and others), to be the product of *Bursera gummifera*, and in the previous report this tree was referred to as yielding the resin. In a letter from Dr. F. Watts, dated 9th March, 1904, referring to Gommier resin, it is stated, however, that the source of this material is *Dacroydes hexandra*.

Chemical Examination.

The consignment of resin was packed in two tins each holding about 26 lb. The material was soft and oily, and had an odour resembling that of turpentine, but rather pleasanter. The outer layers of resin in contact with the tins were very much discoloured by iron rust; internally the material was of a dirty grey colour, and contained much extraneous matter, such as pieces of bark, wood, leaves, and even small stones.

A fair sample of the whole was selected for analysis. The results obtained are shown in the following table, which also gives for convenience of comparison the results obtained with the hard, dry resin, which constituted the bulk of the previous consignment and the average figures given by the Manila elemi of commerce.

	Gommier resin.		*Manila elemi.*
	1st sample. Hard.	2nd sample. Soft.	
Saponification value ...	24·7	35·1	25·72 to 49·98
Acid value	14·1	33·6	17·7 to 24·48
Ester value	10·6	11·3	7·64 to 26·99
Ash (per cent.) ...	0·08	0·19	0·023to 0·93
Melting point	158°-164°	below 100°.	

The resin was completely soluble in alcohol, ether, or turpentine oil.

These results are of interest as showing that the fresh soft resin contains a much larger quantity of free acid and a smaller proportion of ester than the dry resin previously examined. This would appear to indicate that in the drying of the resin a chemical change, involving the conversion of some of the free acid into an ester, occurs in addition to the physical change brought about by the gradual evaporation of the volatile oil.

Commercial Valuation.

Samples of this consignment of Gommier resin were submitted to brokers for commercial valuation. They reported that a considerable fall had recently taken place in the price of Manila elemi which is at present worth only from 25*s*. to 30*s* per cwt. as against 70*s*. to 80*s*. per cwt. at the corresponding period of 1903. It was thought that the sample of the West Indian resin, on account of its unsatisfactory appearance, would not at present be worth more than 10*s*. to 15*s*. per cwt. (October, 1904).

ELEMI FROM SOUTHERN NIGERIA.

Two samples of this material have been received from Messrs. Alexander Miller Bros., of Liverpool.

No. 1 weighed about 4 lb., and was hard enough to retain its shape when cut into fragments. It varied from white to pale yellow in colour, with occasional patches of brown, and contained a good deal of vegetable débris.

No. 2 weighed about 2 ozs., and, like No. 1, was of firm consistence. It was yellowish-green in colour, and contained a small amount of woody matter.

On analysis the following results were obtained:—

—	No. 1.	No. 2.
Ash	0·6	0·53
Acid number	65·3	37·8
Saponification number	71·9	46·2
Yield of volatile oil, per cent.	8·1	4·4
Solubility :—		
Completely soluble in.	Benzene. Turpentine oil.* Turpentine oil + alcohol.	Benzene. Turpentine oil.* Turpentine oil + alcohol
Sparingly soluble in	Cold alcohol.	Cold alcohol.

* In this solvent the oleo-resin dissolves very slowly and not quite completely.

From sample No. 1 a considerable quantity of the volatile oil was prepared by distillation with steam, and this had the following characters:—

—	Characters of the oil from West African elemi.	Characters of the oil from Manila elemi.
Colour	Pale straw yellow.	Colourless or pale yellow
Specific gravity at 15° C. ...	0·8686	0·87 to 0·91 at 15° C.
Specific rotation in a 100 mm. tube.	+ 50° 30′	+ 44° 3′
	Contains a large proportion of phellandrene.	Contains phellandrene.

These results indicate that the Southern Nigeria resin presents a general resemblance to that exported from Manila, and it is probable that if it were carefully collected and exported in a fresh, clean condition, it would be equally serviceable.

The total demand for elemi is, however, small, and it would be an easy matter to overstock the market (May, 1908).

Elemi Resin from Liberia.

A sample of this material, which is occasionally imported into Europe under the name of West African elemi, was received at the Imperial Institute in 1906. It consisted of an oleo-resin, which possessed a pleasant aromatic odour. It was soft and

sticky, though slightly hardened on the exterior, and very dirty, a large quantity of earthy matter, leaves, twigs, and pieces of paper being associated with it. For the purpose of examination, clean pieces of the resin were selected.

The resin dissolved readily in turpentine oil, and less readily in alcohol, chloroform or benzene. A chemical examination gave the following results:—The mean acid value was 22·6, the ester value 22·1, and the saponification value 44·7.

On distillation by means of a current of steam, about 11 ccs. of volatile oil were obtained from 100 grams of resin; the specific gravity of this oil, which was dextro-rotatory, was 0·8679.

The principal constituent of the resin is a crystalline substance melting at 167° C., and closely resembling in properties the crystalline substance obtained by More from the oleo-resin of *Dacryodes hexandra* (*Journ. Chem. Soc.*, 1899, 718). Unfortunately no information was supplied with this sample as to its botanical origin, and consequently it is impossible to say whether or not it is yielded by one of the species known to yield the elemi resins of commerce.

These results show that the resin resembles elemi in properties and composition. It would, however, have little or no commercial value in the dirty condition of this sample (January, 1907).

UGANDA ELEMI FROM *Canarium Schweinfurthii.*

This was forwarded for examination to the Imperial Institute in February, 1908.

The sample consisted of about 8 lb. of oleo-resin, varying in colour from white to pale yellow, and containing a considerable quantity of darker material mixed with woody matter. The whole sample had a dirty appearance, and the paler coloured resin was only apparent when the sample was cut.

A chemical examination of the resin gave the following results:—

Ash (on average sample) per cent.	0·3	
Acid number	29·4	These constants were determined on a picked, clean sample of the oleo-resin.
Saponification number ..	44·8	

An average sample subjected to steam distillation gave 11·2 per cent. by weight of a pale, straw-yellow, essential oil, containing much phellandrene, and having a specific gravity of 0·8451 at 15° C., and an optical rotation of +79° 20′ in a decimetre tube.

The qualitative solubilities of the oleo-resin were as follows:—

Alcohol	Sparingly soluble in the cold.
Turpentine oil	Slowly and incompletely soluble.
Benzene	Readily and completely soluble.
Turpentine oil and alcohol	Readily and completely soluble.
Benzene and alcohol ...	Readily and completely soluble.

These data are sufficient to show that the Uganda elemi, like that from Southern Nigeria, presents a general resemblance in properties to Manila elemi, the principal difference being in the smaller yield of volatile oil from the African kinds. It is probable that the African elemis, if carefully collected and stored so that they could be put on the market in a soft, clean condition, comparable with that of good qualities of Manila elemi, would be equally serviceable as ingredients in the manufacture of printing inks and varnishes; but, as already indicated, the total demand for elemi is small, and if large quantities of these products were put on the market they would probably be unsaleable (May, 1908).

COLOPHONY OR COMMON ROSIN.

This product is the cheapest and commercially one of the most important of the resins. It is obtained as a by-product in the distillation of oil of turpentine from the crude turpentine obtained by the tapping of various species of Pinus. The principal centres of production are the United States, France, and Russia, though small quantities are manufactured, mainly for home consumption, in Austria, Algeria, India, and elsewhere. It is used for a great variety of purposes in the arts, but perhaps the most important of these are the manufacture of cheap household soaps, inexpensive spirit varnishes, resinates to be used for varnishes, enamels, and "driers," and lastly for the production of "resin spirit" and "resin oil" by its destructive distillation.

The imports of rosin into the United Kingdom in 1907 were valued at £896,301 of which £693,065 came from the United States and £136,092 from France. The present value of rosin in the United Kingdom is about £8 per ton.

The only British Dependencies in which considerable areas of pine trees suitable for the production of turpentine oil and colophony occur are India and British Honduras, and in the former the preparation of these two products on a small commercial scale has been undertaken by the Forest Department.

In connection with this undertaking a number of samples of Indian turpentines, turpentine oils, and colophony have been examined at the Imperial Institute with a view to ascertaining whether the two latter products were suitable for export to the United Kingdom. The work on turpentine oil will be dealt with in the "Collected Reports on Volatile Oils" to be published in this series, and in the present compilation only the crude turpentines (oleo-resins) and the colophony will be considered.

TURPENTINE AND ROSIN FROM INDIA.

The following samples of these products have been received from India for examination:—

No. 1.—Colophony from *Pinus longifolia*. Naini Tal, United Provinces. Received in 1905.

No. 2.—Colophony from *Pinus longifolia*. Kangra Division, Punjab. Received in 1906.

No. 3.—Crude turpentine from the Naini Tal Division, United Provinces. Botanical origin not stated. Received in 1908.

No. 4.—Crude turpentine from *Pinus excelsa*. Punjab. Received in 1908.

No. 5.—Crude turpentine of *Pinus Gerardiana*. Punjab. Received in 1908.

Results of Examination.

Crude Turpentines.

The three oleo-resins received, Nos. 3, 4, and 5 in the foregoing list of samples, have been chemically examined with the following results:—

—	Yield of oil (by weight) Per cent.	Character of oil.	
		Specific gravity at 15°C.	Optical rotation in 100 mm. tube.
No. 3. From Naini Tal, United Provinces (botanical source not stated.)	12·7	0·8724	+ 3° 7′
No. 4. *Pinus excelsa* from the Punjab	20·6	0·8613	+ 35° 25
No. 5. *Pinus Gerardiana* from the Punjab.	23·0	0·8659	+ 24° 54′

It will be seen from these results that the yield of oil from the crude turpentine from Naini Tal is very much lower than that from the other two specimens. In all three cases, however, the figures quoted are probably below those obtainable in practice, since unless special precautions are taken there must be a considerable loss of oil from the crude turpentine during storage and transport. The yields of oil obtained from crude turpentine in France and the United States of America are stated to be as a rule between 20 and 30 per cent., but they vary with the district, the species of tree operated upon, and the number of times the tree has been tapped. Full information is no doubt available in India regarding the usual yields of oil obtained from the crude turpentine distilled, and it would be interesting to know how the average compares with that secured in France and the United States.

Colophony or Rosin.

The following specimens of colophony have been examined:—

(*a*.) Colophony of *Pinus longifolia* from Naini Tal, United Provinces (No. 1 in list of samples).

(*b.*) Colophony prepared at the Imperial Institute from the crude turpentine (botanical source not stated) from Naini Tal, United Provinces (No. 3 in list)

(*c.*) Colophony prepared at the Imperial Institute from the crude turpentine of *Pinus excelsa* from the Punjab (No. 4 in list).

(*d.*) Colophony prepared at the Imperial Institute from the crude turpentine of *Pinus Gerardiana* from the Punjab (No. 5 in list).

The specimen of the colophony of *Pinus longifolia* from the Punjab (No. 2 in list) was very similar to (*a*) above, and was not examined.

The results of the examination are given in the following table:—

—	(*a.*)	(*b.*)	(*c.*)	(*d.*)
Melting point...	75° 85°C.	—	—	—
Specific gravity	1·067	—	—	—
Ash, per cent....	0·125	—	—	—
Saponification value* ...	190·0	193·0	194·0	176·0
Acid value	165·0	170·1	170·0	174·0
Unsaponifiable matter, per cent.	5·0	3·8	9·0	6·9
Specific rotation	+ 9° 40′	Nil	— 4° 48′	+ 11° 20′

* *Milligrams of potash per gram of colophony.*

For comparison with these results the following figures obtained for typical samples of the American and Bordeaux colophonies of commerce may be quoted:—

	American.	Bordeaux.
Saponification value	184·0	184·0
Acid value	175·6	175·0
Unsaponifiable matter, per cent.	6·5	—
Specific rotation	+29° 5′	0·0

The results of the examination show that there is little difference in composition between the Indian colophony and that procured from the United States and France. The Indian sample (*a*) from Naini Tal was rather dark in colour, and for that reason would rank as of low grade, but there appears to be no reason why, if reasonable care is exercised in the collection of the crude turpentine and in its distillation, a pale yellow rosin should not be produced in India.

Commercial Valuation of Indian Colophony.

Samples of the first three rosins, viz. (*a*), (*b*), and (*c*), referred to above, were submitted to rosin importers and to soap manufacturers for valuation and trial. The former reported that (*a*)

would be worth £7 per ton, (*b*) £8 per ton, and (*c*) £12 per ton. The soap-makers stated that (*a*) and (*b*) would be too dark for their purposes, but might be suitable for use in paper manufacture, and for that purpose would be worth from £9 6s. to £10 per ton, whilst (*c*) would be suitable for soap-making, and worth £11 per ton in this country.

Sample (*d*) was not valued, but it would probably fetch similar prices to sample (*c*) The rosin importers mentioned that owing to the high prices at present prevailing for rosin it is probable that Indian colophony could now be exported to this country at a profit, and they stated that they would be willing to give a trial order at any time in order to start the exportation to this country if that is possible (May, 1909).

MISCELLANEOUS RESINS.

Benzoin from the Federated Malay States.

This sample of benzoin was sent to the Imperial Institute by the Curator of the Selangor State Museum, Kuala Lumpur, in November, 1905. It was stated that the product was derived from a species of Styrax, which is fairly common in the neighbourhood of Kuala Lumpur, and that considerable quantities might be forthcoming if the value of the resin were sufficient to make its collection remunerative.

Description of Sample.

The sample, which weighed 14 oz., consisted of a single, roughly-ovoid lump of brown resin, which had the characteristic odour of benzoin.

Chemical examination.

Chemical examination established the identity of the resin with benzoin, and showed that it most resembled the variety of this product known commercially as Palembang benzoin. It contained 1·61 per cent. of moisture, 0·41 per cent of ash, and 91·48 per cent. of resin soluble in alcohol.

Conclusions.

Material represented by the present sample could be used instead of Palembang benzoin for all purposes to which the latter is applied.

The benzoins official in the "British Pharmacopœia" are the Siam and Sumatra varieties, which are derived from *Styrax Benzoin*. The application of the Palembang and other varieties is therefore limited to the preparation of incense and the manufacture of benzoic acid, the latter being the more important use.

The commercial value of this benzoin from the Federated Malay States would be about the same as that of Palembang benzoin. The latter was quoted in London on the 24th February, 1906, at £2 8*s*. to £2 10*s*. per cwt. for ordinary quality, whilst a consignment of good quality was sold at £3 8*s*. per cwt. on the 2nd March last. The present sample would probably sell as ordinary quality.

LADANUM FROM CYPRUS.

A specimen of ladanum, obtained in Cyprus from species of *Cistus*, was sent to the Imperial Institute in February, 1907, with the request that the product might be examined and reported on.

It consisted of two thick circular cakes each weighing about 13 ounces. The material was homogeneous, had a dark slatey-brown colour, and a pleasant aromatic odour. It was hard at the atmospheric temperature, but softened when kept in the hand, forming a plastic mass.

Gum ladanum or labdanum was formerly employed to a small extent in pharmacy, but has long passed out of use. It was at one time given internally, but its most recent use was as an ingredient in plasters. Some years ago small quantities appear to have been annually exported to Constantinople from Crete and Cyprus, and were stated to be employed by the Turks for fumigation and also to some extent as a perfume.

Commercial Valuation.

A firm of manufacturing druggists, to whom a sample of the material was submitted, stated that they were not aware that ladanum was used in pharmacy or perfumery at the present time. They were of opinion, however, that the material represented by the sample might be utilised in perfumery for some of the purposes for which ambergris is employed, *i.e.*, to make a basis for more delicate odours.

In view of this statement samples of the ladanum were submitted to two firms of manufacturing perfumers. One firm stated that up to a few years ago they employed ladanum for certain purposes, but had abandoned its use entirely now. The specimen from Cyprus appeared to them to be a particularly fine sample of the product, but they could not suggest any use to which it could now be put.

The other firm of perfumery manufacturers, after a careful examination of the sample, also stated that the material was of no value for their purposes (July, 1907).

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Botanical names are printed in italics.

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No. 71.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT.

Edited by the DIRECTOR.

III.—FOODSTUFFS.

(For Part I., Fibres, *see* No. 58 [Cd. 4588] of 1909. For Part II., Gums and Resins, *see* No. 63 [Cd. 4971] of 1909.)

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No. 71.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

III.—FOODSTUFFS.

INTRODUCTION.

The first part of this series of publications related to fibre, (Cd. 4588, 1909) and the second part to gums and resins (Cd. 4971, 1909). The present third part mainly deals with various foodstuffs which have been examined in the period 1903 to 1907 at the Imperial Institute, chiefly at the instance of the Governments of the Colonies and India.

Included for convenience among foodstuffs are the well-known stimulants tea, coffee, and cocoa. Attention may be drawn here to the success which has attended the cultivation of tea in Natal, the production of which amounted in 1908 to 3,278,464 lb. At first Natal tea was almost entirely consumed in South Africa, but now an export trade with other countries is developing, and in 1908 271,931 lb. were sent to the United Kingdom. Natal tea stands intermediate in its characters between the teas of China and those of India and Ceylon.

In connection with cocoa some account is given of the important work which has been carried on at the Imperial Institute in recent years in promoting the production in the Gold Coast of a higher quality of cocoa than that generally grown, and in introducing this cocoa to the British market. Cocoa production in this Colony has made rapid strides in the last few years. The export for 1908 was 12,744 tons, of the value £540,821, and cocoa production is now firmly established and is already the most important agricultural industry of the Colony. Hitherto there has been a large demand on the Continent for the inferior grades of Gold Coast cocoa which are unsuitable for the British manufacturer. With the improvement in quality which is now taking place it is probable that British manufacturers will take a larger share of the output, and in this connection the Imperial Institute has been in communication with several firms, including Messrs. Cadbury, who have taken an active interest in the subject.

The examination of new or little known foodstuffs hitherto principally or exclusively used by natives in the Colonies has been

the means of bringing to light several materials which may prove to be of value. Among these may be mentioned the yeheb or yebb nuts of Somaliland.

An important investigation which has now been in progress at the Imperial Institute for some years is that relating to the poisonous properties occasionally exhibited by well-known fodder plants and foodstuffs such as sorghum, cassava, linseed, and the beans of species of Phaseolus. This investigation has led to the discovery that in these and other cases the poisonous effects are due to the existence in various parts of the plant of what are now known as cyanogenetic glucosides from which prussic acid is readily produced.

In order that the results of the investigations of foodstuffs may be better appreciated, a brief account of the principal facts relating to foods and their value is given.

The work involved in the investigations here recorded has been carried on by several members of the staff of the Scientific and Technical Department, and recently has been in charge of Mr. H. H. Robinson, M.A. (Oxon.). The Imperial Institute is indebted to many firms of merchants, brokers, and manufacturers for the interest they have taken in the subjects brought under their notice and for the great assistance they have rendered on the commercial side of these investigations.

WYNDHAM R. DUNSTAN.

January, 1910.

FOOD CONSTITUENTS AND THEIR FUNCTIONS.

The constituents of food have to furnish the animal with fuel and with repairing materials to make good the daily wear and tear of its various organs. The fuel is required to keep up the temperature of the body and to supply the energy necessary for the work that is done both externally in the form of mechanical labour and internally in maintaining the circulation of the blood and other vital functions. The framework of the body is composed of water, of nitrogenous materials, of fat, and of mineral matter or ash constituents; all these are constantly suffering losses which have to be replaced in the adult and more than replaced in the growing animal since an additional quantity is required to supply the increase in weight.

The supply of water to the animal usually presents but little difficulty, and it is not often that any consideration is required as to the supply of mineral or ash constituents, since most diets contain ash both sufficient in quantity and comprising the requisite elements. An interesting case, however, in which this question was raised, occurs in the report on the composition of oat ash, as bearing on the bone disease of horses in Cape Colony (p. 205). The critical examination, therefore, of a foodstuff is chiefly directed to the proportions and nature of the carbon compounds, both nitrogenous and non-nitrogenous, that it contains;

attention must also be given to the possibility of the presence of poisonous substances.

The most valuable of the nitrogenous compounds are those belonging to the group of albuminoids, of which albumin, the solid matter of white of egg, is the type. It is a large group, the members of which are found in plants and in animals. The latter are believed to be entirely dependent for their supply of albuminoids on those elaborated in the vegetable kingdom; that is to say, the animal body cannot produce an albuminoid from non-albuminoid materials, though it can transform one albuminoid into another. The "proteins" or "proteids" are other names that have been given to this group. The albuminoids in the food, after digestion pass into the blood and are transformed into the muscle, nerves, and cartilaginous substances of the body, hence they are often known as the "flesh formers."

Besides the albuminoids, other nitrogenous substances are found in foods which have a simpler chemical constitution and which are incapable of being transformed into muscle, nerves, &c., although they may act as heat and work producers. In the analysis of a food, consequently these two classes have to be separated; the former being reported as albuminoids and the latter as "non-albuminoid nitrogenous substances." In mature vegetable products such as seed grains, the nitrogenous substances are almost entirely albuminoids, but in immature vegetable produce, such as the roots and leaves of growing plants, a considerable proportion of the nitrogen is present in non-albuminoid combinations, among which are the amides.

The non-nitrogenous substances which are of feeding value are the members of the group of fats and oils and those of the group of carbohydrates which includes starch and sugars of various kinds; these, after absorption into the body, are oxidised and supply the energy necessary to produce heat and work, and, if in excess beyond the animal's daily requirements, can be stored up as fat for future use. Weight for weight the fats and oils are far more effective sources of heat than the carbohydrates, and are usually reckoned as being 2·3 times as valuable. Besides the nutritive constituents most vegetable foods contain a certain proportion of fibre. This is not digestible, yet it has a certain mechanical value in that it is adapted to meet the needs of the digestive tract, especially in the case of ruminating animals, which are adapted for extracting nourishment from bulky fibrous foods. It should be mentioned too that with the carbohydrates there are also included in analyses certain substances, such as the gums and the members of the pectose group, which are not strictly carbohydrates though very closely allied to them.

Since the albuminoids have a function in the diet which they alone can perform, it is found useful in considering the composition of a food or of a diet to calculate what is termed the "albuminoid ratio" or "nutrient ratio." This is found by multiplying the amount of fat by 2·3 and adding the product to the amount of carbohydrates; the sum is then divided by the amount of albuminoids and the ratio of unity to the quotient is the

"albuminoid ratio." Another calculation that is made is to find the "nutrient value"; this is obtained by multiplying the percentage of fat by 2·3 and adding together the product and the percentages of albuminoids and of carbohydrates. It is useful in comparing the amount of nourishment in one food with another. It should be mentioned that the albuminoids, besides acting as flesh formers, can also, like the fats and carbohydrates, be oxidised in the body, supplying energy.

The reports are grouped for convenience under the following heads:—

I. Food Grains.

II. Miscellaneous Foodstuffs.

III. Tea, Coffee, Cocoa, &c.

The residual cakes left by many of the oil seeds when these are pressed to obtain the oil, serve as valuable foods for the live stock of the farm; they are, however, most suitably treated of in conjunction with the seed and its oil, and an account of those that have been examined at the Imperial Institute will be found in the "Selected Reports on Oils and Oil Seeds" which will shortly be published.

I.—FOOD GRAINS.

Supply of Food Grains to the United Kingdom.

The principal food grains produced in the United Kingdom are wheat, barley, oats, beans, and peas; the home supply of these is largely supplemented by imports from abroad, and in addition we receive large quantities of maize and rice, grains which will not ripen in these islands. In 1907 the total supply of these grains to the United Kingdom was 17 million tons, of a value of 120 million pounds sterling. The items that form these totals are shown in the following tables:—

Supply of Food Grains to the United Kingdom in 1907.*

—	Produced in the United Kingdom.	Imported from British Possessions.	Imported from Foreign Countries.	Total Imported.	Total from all Sources.
	Tons.	Tons.	Tons.	Tons.	Tons.
Wheat ...	1,514,228	2,101,747	3,680,081	5,781,828	7,296,056
Barley ...	1,497,597	99,016	882,365	981,381	2,478,978
Oats	3,198,152	77,870	446,394	524,264	3,722,416
Beans ...	315,608	7,566	32,412	39,978	355,586
Peas	135,593	23,522	38,762	62,284	197,877
Maize ...	—	140,027	2,528,970	2,668,997	2,668,997
Rice	—	232,292	175,885	408,177	408,177
Total ...	6,661,178	2,682,040	7,784,869	10,466,909	17,128,087

* For note see page 204.

Value of the Supply of Food Grains to the United Kingdom in 1907.*

—	Produced in the United Kingdom.	Imported from British Possessions.	Imported from Foreign Countries.	Total Imported.	Total from all Sources.
	£	£	£	£	£
Wheat ...	11,983,435	16,545,724	27,494,906	44,040,630	56,024,065
Barley ...	11,077,223	626,701	5,937,969	6,564,670	17,641,893
Oats	20,856,327	514,428	2,869,125	3,383,553	24,239,880
Beans ...	2,367,060	47,126	243,567	290,693	2,657,753
Peas	1,322,032	197,346	405,302	602,648	1,924,680
Maize ...	—	778,958	13,825,546	14,604,504	14,604,504
Rice	—	1,880,159	1,456,695	3,336,854	3 336,854
Total ...	47,606,077	20,590,442	52,233,110	72,823,552	120,429,629

* In compiling these two tables from the statistics available, in the case of the produce of the United Kingdom the quarter of wheat has been taken as 480 lb. and its value as 33*s.* 11*d.*; that of barley as 400 lb. with value 26*s.* 5*d.*: that of oats as 312 lb. with value 18*s.* 2*d.*; that of beans as 528 lb. and the value as £7 10*s.* per ton; that of peas as 512 lb. and the value as £9 15*s.* per ton. The weight of wheat imported includes the flour imported converted into its equivalent weight of grain, reckoning that 72 tons of flour are obtained from 100 tons of grain. The value of the wheat imported includes the value of the flour imported. Peas includes whole and split peas. Rice includes also rice flour and rice offals.

These figures show that there is great scope for developing the production and export of grain to the United Kingdom in the British Possessions, many of which possess soils and climates well suited to the growth of the various cereals and legumes. Besides the above staple food grains various others are imported into the United Kingdom; among these are lentils; chick peas (*Cicer arietinum*) known as gram in India; pigeon peas or dhol (*Cajanus indicus*); and various millets, the most important of which is the great millet or guinea corn (*Sorghum vulgare*) also known as dari or durra. The amounts of these imported in 1907 are given in the table that follows, which is succeeded by reports made on various samples of food grains that have been received at the Imperial Institute, and by an account of the cyanogenetic glucosides, a group of substances occurring in various plants and capable under certain conditions of generating prussic acid and thus causing poisoning in men and animals.

Imports of various Food Grains into the United Kingdom in 1907.

—	Weight.			Value.		
	Consigned from		Total.	Consigned from		Total.
	British Possessions.	Foreign Countries.		British Possessions.	Foreign Countries.	
	Tons.	Tons.	Tons.	£	£	£
Great Millet, or Dari or Durra	14,346	10,746	25,092	77,845	55,000	132,845
Millet	53	4,683	4,736	412	28,889	29,301
Lentils, whole and split	10,143	1,268	11,411	83,519	11,472	94,991
Dhol or Pigeon Pea, together with Gram or Chick Pea ...	31,103	37	31,140	194,641	558	195,199

"EGYPTIAN BARLEY" FROM THE EAST AFRICA PROTECTORATE.

This sample was described as "sown on the 29th October and reaped on the 6th February."

The barley was valued at about 22*s*. per quarter of 400 lb. (August, 1905).

OATS SENT FROM CAPE COLONY BUT OF VARIOUS ORIGINS.

Owing to the spread of bone disease, which some of the veterinary officers considered possibly due to defective feeding, an idea had got abroad in Cape Colony that Western Province forage was unsuitable for the feeding of military horses; on the other hand the view was also held that the disease was imported and had nothing to do with Cape forage.

Three samples of oats were received for analysis in 1905; they were stated to have been sent with a view to arriving at the mineral constituents of various qualities of oats placed on the market in Cape Colony. It appeared later that they were not all grown in Cape Colony.

Each sample consisted of about six pounds of oats, and a representative specimen of each was selected and carefully and completely burned. The mineral residue so obtained was then chemically examined, those constituents which are of importance in the formation of bone being estimated. The results are shown in the following table, which also gives the amounts of the same constituents usually present in oats grown in other countries:—

—	Oats received from Cape Colony.			United States Mean of 45 samples.	Canada Mean of 12 samples.	Germany Mean of 57 samples.	England Mean of 11 samples.
	Sample No. 1.	Sample No. 2.	Sample No. 3.				
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Amount of ash left on ignition	3·3	3·4	3·3	—	—	—	—
Composition of ash :—							
Potash, K_2O	14·0	10·41	11·06	15·91	20·74	16·38	16·6
Soda, Na_2O	0·99	0·85	0·98	4·38	2·16	2·24	2·6
Lime, CaO	1·11	3·54	1·52	4·09	5·93	3·73	3·8
Magnesia, MgO... ...	5·65	4·39	4·04	7·19	9·41	7·06	7·0
Phosphoric acid, P_2O_5 ...	15·76	10·76	15·16	24·34	22·36	23·02	22·6
Silica, SiO_2	51·38	63·38	58·83	42·64	38·06	44·33	44·9

The figures given in this table show that, as compared with those produced in America and European countries, these oats contain unusually small proportions of potash, lime, magnesia, soda, and phosphoric acid, whilst they contain comparatively large quantities of the less useful substance silica. Of these constituents the most important from the point of view of the formation of bone are lime, magnesia, and phosphoric acid, since "bone ash" has approximately the following composition:—

	Per cent.
Lime	38·5
Magnesia	0·5
Fluorine	1·8
Phosphoric acid	53·2
Carbonic acid	6·0

It is evident therefore that these oats are deficient in these mineral constituents which are of greatest importance in the formation of bone. In the letter and enclosure accompanying the samples of oats, no information is given as to the precise nature of the bone disease which it is alleged is produced by the use of oats grown in the Western Province of the Colony as forage, and, consequently, it is impossible to say definitely whether the deficiency of these oats in certain constituents is the cause of this disease or not, but it is obvious that, under certain circumstances, and especially with horses accustomed to forage richer in bone-forming mineral constituents, the use of these oats as fodder might be injurious.

The cause of the deficiency of these oats in certain mineral constituents is probably to be found in the nature of the soil upon which they are grown, and their defects in this respect could no doubt be remedied by the application to the soil of appropriate chemical manures.

Beans from the East Africa Protectorate.

A considerable amount of attention has been paid in the Protectorate to the cultivation of beans of various kinds suitable for use as feeding-stuffs, and samples of "Egyptian" and "dwarf" beans grown during the season 1904-1905 have been

received for valuation. Both were described by experts as of good quality, and as regards the dwarf beans it was suggested that small consignments could probably be readily sold in the United Kingdom for seed purposes, and since then several small shipments of these beans have been made to the United Kingdom, where they appear to have given good results when used as seed.

Beans and Peas from Abyssinia.

The samples were examined and valued with the following results:—

Ful, Beans.—This sample consisted of light brown beans, clean and free from other seeds. It was valued at about £5 10*s.* per ton in London (March, 1906).

Basla (Bisillah), Peas.—The peas were not of good colour and were valued at 27*s.* 6*d.* per 504 lb. (March, 1906).

Both of these would be suitable for export, either to Europe or the neighbouring countries.

Maize from Ceylon.

Three samples of maize were received for valuation.

Sample No. 1: Pure White Dent.—This was of good quality and was valued by the brokers at 19*s.* per quarter of 492 lb. Sample No. 2: Crossed Dent.—This was reported to be of the same quality as the maize grown in Egypt and to be worth from 17*s.* 6*d.* to 18*s.* 6*d.* per quarter of 492 lb. Sample No. 3: Crossed Flints.—This consisted of a mixture of grain of various qualities and its value was stated to be 18*s.* per quarter of 492 lb. (June, 1904).

Memorandum on the Harvesting and Shipment of Maize, with reference to West African Requirements.

Gathering.—The common method of harvesting maize is to "pull" the ears, with a good portion of the husks attached, leaving the stalks and leaves, which are utilised as fodder.

The corn must be husked before it can be shipped, and in general before it can be used. Husking can be done more rapidly and with less expense as the corn is being gathered than at any other time, and under ordinary circumstances that is the best time for doing the work.

The practice of gathering and storing maize with the husks still enclosing the ears is advocated by many from a belief that the husks serve to protect the grain from the attacks of insects. The two insects which are most destructive to stored grain in America are the Angoumois grain moth (*Gelechia cerealella*) and the black weevil (*Calandra oryzæ*), and as the maize is often infested by one or both of these insects whilst still in the field, there is little to support the idea that the husks serve as a protection against them. The husks add materially to the bulk of the

stored corn, they afford no protection from insects, and provide a good nesting material for rats and mice.

Cribbing.—After gathering, the ears of maize are put into a crib made of poles stuck in the ground with wire and cornstalks woven in among them, forming a sort of bin. This being more or less open allows the air to circulate through and dry the corn, especially if the crib is thatched over.

Shelling.—Machines or "corn-shellers" of the following types are supplied by Messrs. Peter Henderson and Company, New York:—

(1.) The "Burrall Corn-sheller," which can be worked by one man. Capacity, 100 bushels per day. Price, 6·75 dollars.

(2.) The "Clinton Corn-sheller."—This machine does not separate the corn from the cob. Price, with one balance wheel, 4·50 dollars; with two balance wheels, 5·50 dollars.

(3.) The "Black Hawk Corn-sheller."—A small hand machine. Price, 2 dollars.

Messrs. Ruston, Proctor and Co., Lincoln, England, supply an "Improved Maize Husking, Shelling, and Dressing Machine," the action being as follows:—The cobs fall upon a revolving drum, which strips off the grain. The grain is cleaned from dust, loose husk, and other refuse by riddles and by a strong current of air, and is elevated to the sack-spouts in a finished condition. The machine, which is provided with a portable feed elevator, is made in two sizes:—(1) The 3 ft. 6 in. machine shells and dresses about 400 quarters of maize in 10 hours, and can be driven by a six horse-power portable engine; (2) the 5 ft. machine shells and dresses about 850 to 900 quarters in 10 hours, and can be driven by a 10 horse-power portable engine. In the case of both machines, if husking is done at the same time, the output will be about half the quantities named above.

Cleaning.—The object of cleaning is to take out the "fluff" which contributes to the chance of heating on the voyage. Cleaning, as a separate operation, may be desirable if the shelling machine cleans the grain imperfectly.

Drying.—Great care is necessary to dry the maize thoroughly and to ship it in a dry condition. The general opinion among the most successful shippers is that there is practically no danger of damage to the cargo during the voyage if the following conditions are observed:—(1) if a ship carrying maize sails within 15 or 20 days after she begins to load; (2) if the loading has been done with dry grain in dry weather; and (3) if the hatches of the ship are securely battened down, and, as nearly as possible, hermetically sealed during the entire voyage. Shippers appear to have largely abandoned the practice of ventilation.

Loading.—The least possible time should elapse between the time of shelling the maize and loading it on ship.

Maize is usually exported from Argentina in bags of about 155 pounds weight. In 1902 it was estimated that 90 per cent.

of the maize exported was in bags and only 10 per cent. in bulk. The proportion of bulk shipments is now somewhat greater. Sometimes cargoes contain both bagged and loose corn.

At Buenos Aires and La Plata the bags are either carried on board by men or swung on from cars alongside the docks by hydraulic cranes or steam winches. Maize to be shipped in bulk is always carried on board in bags, which are opened and emptied in the hold.

At Rosario the principal method of loading the bags is by means of "canaletas," which are long, wooden chutes, made in sections and swung on cables from the elevator or warehouse on a high bank of the river to the ship lying below. In some cases grain has been loaded in bulk by the same system. In another part of the port, where there are no high banks, hydraulic cranes and steam winches are used. At the smaller ports on the Parana and Uruguay rivers the "canaletas" are also used.

At Bahia Blanca grain is loaded (1) by steam winches from the cars; (2) by men carrying the bags on board; and (3) by a system of endless chains, carrying the bags a distance of about 100 feet from the cars to the ship's side, where they are slid into the hold. Some lightering is done when the mole is crowded and ships are waiting. The lighters are of 350 tons burden and the charge is 30 cents per ton. The bags are lifted from the lighters by steam winches on board the ships.

Care on Board Ship.—Temporary wooden bulkheads are sometimes put in front of the engine-room, leaving an air chamber a foot wide, which is kept well ventilated in order to prevent the corn from becoming "heated." This, however, is an unusual precaution and not the rule.

Pests.—The modern treatment for grain weevils and moth is fumigation with bisulphide of carbon.

It may be applied either by spraying or pouring the liquid over the grain, but it is commonly put in shallow pans, and the vapour sinking through the maize suffocates the insects.

The best results are obtained when the grain is stored in air-tight bins or closed tanks; but in distant regions, or wherever the farmer cannot afford to erect substantial buildings, covering the grain with tarpaulins, oil-cloths, or canvas sails will be found quite effective.

It is often a good plan to build a "quarantine bin" in which the grain is placed directly it comes from the field. Here it is treated and afterwards removed to the open cribs or maize store.

The bisulphide is used at the rate of 1 lb. to each 100 bushels of grain, and this amount has proved to destroy insects even in open cribs.

Mills and other buildings may be fumigated in like manner.

As bisulphide of carbon is very inflammable, great care should be taken to avoid any risk of explosion, and no lantern, lights, or pipes should be permitted in the bins so long as any odour can be detected. The vapour is poisonous and should not be breathed.

There is, at present, no practical method of combating these insects in the field.

Another device for destroying moths is to agitate the grain by shovelling; the delicate soft bodies of the moths in trying to escape are crushed beneath the falling mass of maize.

Varieties of Maize in demand in England.—All varieties of maize find a ready sale in England, the prices being regulated by the quality and condition of the grain.

The following varieties are those imported into England in the largest quantities at the present time. The price per 100 lb. on the 8th October, 1906, was as follows:—

	s. d.		s. d.
A. American mixed prime	4 11	to	4 11½
B. Cinquantina	5 3	,,	5 4
C. Yellow La Plata	4 2¼	,,	4 2½

West African maize from a cargo received at Liverpool was valued at 4*s*. 7*d*. per 100 lb.

Present defects of West African Maize.—A hindrance to the development of the trade in maize with West Africa is stated to be the more or less damaged condition in which shipments arrive, there being often a difference of 5*d*. or more in the value of one portion of the cargo as compared with another. The cause of this damage remains to be determined; it may arise from bad harvesting or from defective handling before shipment.

Another point which will require attention in connection with West African maize is the prevention of insect pests, as if the grain arrives in a " weevilly " condition its value is very greatly depreciated.

In the case of the Argentine and American maize the principal defect is not the presence of weevils but the heated condition of the grain on its arrival at its destination. Owing to insufficient drying of the grain after harvesting, the moisture retained generates heat during transit, and this causes serious deterioration in the quality and value of the maize.

Present state of the Market for Maize.—During the last two years comparatively high prices have been obtained for maize. Some years ago " American mixed " maize was as low as 2*s*. 9*d*. per 100 lb., but it does not appear likely that the price will fall again to such a low level. American growers are giving so much attention to cotton that an excessive supply of maize does not appear to be probable in the immediate future. (November, 1906.)

Rice from Pemba.

The Vice-Consul stated that a great many varieties of rice thrive in the island, and that those locally known as " Sufala," " Ambari," and " Nondo," respectively, are most generally favoured as they yield the largest returns in proportion to the amount of seed sown, but that as regards quality the variety

known as "Sena" takes the highest rank on account of its superior flavour. The Vice-Consul pointed out that prior to the extensive cultivation of the clove, Pemba was celebrated for its rice, which then constituted an important article of export, but that the amount grown in the island does not suffice for local consumption, and that during 1900 Indian rice of the value of over £22,000 was imported; that, with a little encouragement and help from the Government in the direction of assisting growers to procure the necessary quantity of seed rice, it seemed likely that not only could the local demand be supplied but that rice would again appear upon the export list.

For the purpose of valuation samples, both in the unhusked and cleaned condition, were submitted to brokers. They reported in March, 1903, that the unhusked specimens were not of much interest in the London market, but quoted the following values for the cleaned samples:—

	Per cwt.				
	s.	d.		s.	d.
"Sufala"	9	3	to	9	6
"Ambari"	9	9	,,	10	0
"Nondo"	10	0	,,	10	3
"Sena"	8	0	,,	8	3

These quotations were for the rice, in bags of about 2 cwt. each, delivered in London or Liverpool *ex* quay terms; brokerage 2 per cent. The brokers stated that on these terms it was probable that buyers might be found for a few hundred tons, especially as other descriptions of rice were scarce and that moment would therefore be a favourable opportunity for putting it upon the market. They added that owing to the state of the market the prices quoted for the samples were somewhat higher than those which could be depended upon in normal conditions.

It was clear from this report that consignments of rice, represented by these samples, would probably find a ready sale on the English market, but from the Vice-Consul's statement there was no likelihood of any exportation of rice taking place from Pemba during the next few years. It may be pointed out that the variety "Sena" which is locally held to be the highest in quality was valued at a much lower rate than the other three samples by the London brokers. (July, 1903.)

Rice from Northern Nigeria.

This sample of Rice came from the Ilorin Province; it weighed 6 oz. and was partially cleaned and in fairly large grains of rather a dark colour.

It was submitted to commercial experts who reported that it was equal in quality to Bengal rice and worth about 9*s*. 6*d*. per hundredweight, quay terms.

It could not be exported at a profit unless the estimated price in Nigeria and the cost of freight are capable of great reduction. (December, 1907.)

Millets from Abyssinia.

The samples were examined and valued with the following results:—

Dura or Great Millet (*Sorghum vulgare*).—This was a good clean sample of dura, which was valued at £5 per ton in London. It would be suitable for export, either to Europe or the neighbouring countries.

Nabig.—This product is apparently a very small millet, in which, the brokers stated, there is no trade whatever in this country. It might be worth, they considered, about £4 10*s*. per ton.

Talban.—This was a sample of "ragi," the product of *Eleusine coracana*. This grain is used as a foodstuff in some parts of India, but there is no market for it in this country. The brokers quoted £4 10*s*. per ton as its probable value. (March, 1906.)

Millets from Northern Nigeria.

These samples of millet came from the Ilorin Province of Northern Nigeria; they consisted of:—

(1.) "Red Guinea Corn," in good condition, very few of the grains being weevilled.

(2.) "White Guinea Corn," in fair condition, about five per cent. of the grains having been attacked by weevils.

(3.) Millet from Pateji (local name "Gero," *Pennisetum spicatum*); the sample was in good condition and but little attacked by weevils.

Samples of all the grains were submitted to commercial experts who reported that the white guinea corn ("White Dari") was a fair sample, and that, although not so good as the best grains from Smyrna or Syria, it would compete with them. They stated that it was superior to Indian dari and valued it at 26*s*. per 480 lb. in this country.

The red guinea corn ("Red Dari") was stated to be superior to Indian red dari and was valued at 24*s*. per 480 lb.

The millet ("Gero") was stated to be unknown to English buyers, and, consequently, an analysis would be required so that its composition could be compared with that of other food grains. The sample sent from Northern Nigeria was unfortunately insufficient for the purpose of chemical examination.

These grains could not be exported at a profit unless the estimated price in Nigeria and the cost of freight are capable of great reduction. (December, 1907.)

Lentils from the East Africa Protectorate.

The sample was described as sown 22nd April and reaped 19th September.

It was considered by the commercial experts to whom it was submitted as equal to Calcutta lentils and worth 21*s*. to 22*s*. per quarter of 504 lb. (August, 1905.)

CHICK PEAS (HUMMUS) OR GRAM FROM ABYSSINIA.

The sample was examined and valued with the following results:—

This was a usual sample resembling the Indian product. The majority of the peas were brown, but a number of black ones were also present. The brown variety is worth about 23*s*. per 504 lb., whereas the black will not fetch more than 21*s*. The two varieties should therefore be kept distinct.

They would be suitable for export, either to Europe or the neighbouring countries. (May, 1906.)

CYANOGENESIS IN PLANTS.*

The term cyanogenesis has been suggested by Dunstan and Henry to describe the production of prussic acid by plants. Reference has already been made in the "Bulletin of the Imperial Institute" on several occasions to the occurrence of cyanogenesis in plants of economic importance to India and the Colonies, which have been investigated in the Scientific and Technical Department of the Imperial Institute. In several cases the examination of these plants has been undertaken at the suggestion of Agricultural or other Departments concerned, owing to the fact that they had proved poisonous to animals ("Bulletin of the Imperial Institute," 1903, **1.** 12 and 112; 1905, **3.** 373). Whilst the subject is of great importance from this point of view, it is of no less interest from the scientific side, since it has been suggested by various authorities that prussic acid, or the derivatives of the acid, which occur in plants may be regarded as primary materials from which plants form some of the constituents necessary to their existence. It is obvious that if this view can be upheld the study of cyanogenesis may ultimately become of practical importance to the agriculturist. At present, nothing definite can be said on this side of the question, owing to the fact that very little systematic investigation into the matter has been made from the botanical side; and though much is now known as to the chemistry of cyanogenesis, in particular as regards the nature of the compounds in which prussic acid appears to be stored up in those plants by which it is secreted, and as to the methods by which this acid is liberated from these compounds, much remains to be done in ascertaining the nature of the primary material from which the acid is first produced by plants, and the process by which this is accomplished. The botanical side of the subject is less developed, though two notable contributions to it have been made by Dr. Treub, Director of the Botanical Gardens at Buitenzorg, Java, who has investigated in detail the external conditions governing the occurrence of cyanogenesis in the two tropical plants *Pangium edule* and *Phaseolus lunatus*.

The foregoing considerations are perhaps sufficient to indicate that the subject is one of considerable importance, and it has been considered advisable to publish in this "Bulletin" the following account of our present knowledge of the subject. A full report on cyanogenesis was presented by Professor

* *Reprinted from the Bulletin of the Imperial Institute*, 1906, **4.** 329.

W. R. Dunstan, F.R.S., and Dr. T. A. Henry to the chemical section of the British Association during its meeting at York, which gives fuller technical details than is possible in the present article. Those interested in the scientific side of the subject may be referred to that report ("British Association Reports," 1906).

The production of prussic acid by a plant was recorded for the first time in 1800 by a pharmacist named Bohm, of Berlin, who obtained it by distilling water which had been in contact with crushed bitter almonds. Though prussic acid was discovered by a Swedish chemist named Scheele in 1782, its poisonous nature was not recognised until 1803, when Schräder explained the toxicity of bitter almonds as being due to the production of prussic acid when the almonds are bruised in contact with water. Even before this time instances of the poisonous nature of certain plants, which we now know to be due to their power of producing prussic acid, had been recorded, thus in the "Liber Exoticorum" of Clusius, published at Leyden in 1605, reference is made to the poisonous nature of cassava, and the remarkable observation is recorded that the roots of this plant are more poisonous when the plant is grown under the dry conditions prevailing in many parts of the mainland of South America than when it is cultivated under the moist conditions of certain of the West Indian Islands. Again Madden, in a paper communicated to the Royal Society of London in 1731, drew attention to the fact that cherry-laurel water, prepared by distilling water in which bruised cherry-laurel leaves had been macerated, was poisonous. The latter case was also explained by Schräder in 1803 as being due to the production of prussic acid. The cases of bitter almonds and cherry-laurel leaves remained until about 1851 practically the only known instances of the production of prussic acid by plants, but since that year the formation of this acid has been detected in a very large number of plants, and in an incomplete list of such plants recently compiled by Dr. Greshoff of the Colonial Museum at Haarlem, about 150 species are enumerated. In most of these cases, investigators have been content to record the fact that prussic acid is produced, and the method of its production has been definitely ascertained in comparatively few instances.

In all the plants in which the chemistry of cyanogenesis has been thoroughly investigated it has been found that the prussic acid is liberated when the plant is ground up either in its fresh moist condition, or if it has been previously dried, when the dried ground plant is placed in water: in every case the presence of water is essential. It has also been found that from all such plants, by appropriate methods, a definite crystalline compound can be isolated, which is quite stable, and can be kept for indefinite periods, but which when dissolved in water and boiled with dilute acids decomposes and evolves prussic acid. This same decomposition, with the production of prussic acid, can also be brought about by various ferments. This may perhaps be conveniently illustrated by an example. By extracting bitter almonds with alcohol, a colourless crystalline substance can be

obtained, which has been named amygdalin. When a solution of the latter in water is boiled with diluted hydrochloric acid (spirit of salt), the mixture acquires the well-known odour of essence of bitter almonds owing to the fact that prussic acid and benzaldehyde (oil of bitter almonds) are simultaneously produced. The same decomposition is brought about if ordinary yeast is added to a solution of amygdalin in water. It may be assumed therefore that this crystalline substance, amygdalin, is the source of the prussic acid and the oil of bitter almonds, which are formed when ground bitter almonds are mixed with water. The agent contained in the bitter almonds which effects this natural decomposition of amygdalin has been found to be a special ferment. The latter, like amygdalin, can be isolated from bitter almonds, and is prepared and sold under the name emulsin. The proof that the production of prussic acid in the bitter almond is due to the decomposition of amygdalin by emulsin is found in the fact that the addition of emulsin to amygdalin, dissolved in water, results in the almost immediate production of prussic acid and oil of bitter almonds.

Amygdalin belongs to a well-defined class of substances known to chemists as glucosides; the latter name indicating that when they are decomposed in the way already indicated by acids or ferments they invariably yield glucose or a similar saccharine substance, in addition to certain more specific products such as the prussic acid and oil of bitter almonds produced in the case of amygdalin. These glucosides may be divided into two classes, according as they do or do not yield prussic acid on decomposition, and it is convenient to describe the former class as cyanogenetic glucosides. The fermentive agents which accompany these glucosides in plants, and which serve to decompose them, are termed enzymes or unorganised ferments, the latter name serving to distinguish them from the organised ferments such as yeast, mould, &c. Recent researches have shown that enzymes are widely distributed in plants and animals, and that many of the functions necessary to life are discharged by them. A general article on unorganised ferments and their industrial application has already been published in the "Bulletin" 1905, **3.** 185, to which reference may be made for fuller information. As already indicated, cyanogenetic glucosides and enzymes capable of decomposing these have been isolated from all the plants in which cyanogenesis has been thoroughly investigated on the chemical side, and it may be convenient here to give a short account of what has been done in this direction since the isolation of the first cyanogenetic glucoside—amygdalin—from bitter almonds in 1830.

Lotusin.

This new glucoside was isolated at the Imperial Institute in 1901 from the Egyptian leguminous plant *Lotus arabicus*, which grows along the banks of the Nile. A general account of this work has already been given ("Bulletin of the Imperial Institute," 1903, **1.** 13), so that no extended reference need be made to it here except to say that on decomposition, by acids or fer-

ments, lotusin yields prussic acid, glucose, and a yellow dye, lotoflavin, which possesses tinctorial properties similar to those of quercetin, the constituent to which the well-known dyestuff "quercitron bark," still largely used by calico printers, owes its dyeing powers. The enzyme or unorganised ferment, which occurs with lotusin in *Lotus arabicus*, was also isolated and studied and was named lotase. A full account of the chemistry of lotusin and lotase is given in a paper contributed by Professor Dunstan and Dr. T. A. Henry to the Royal Society (*see* "Phil. Trans." 1901, B. **194.** 515).

Dhurrin.

This new glucoside was also prepared for the first time at the Imperial Institute from the well-known plant *Sorghum vulgare*, widely grown in tropical and sub-tropical countries for the sake of its edible grain, which forms one of the principal foodstuffs of the natives of India, Egypt, East and West Africa, and elsewhere. The glucoside occurs only in the young green plant, so that *Sorghum* like *Lotus arabicus* is only temporarily poisonous, and the conditions under which the glucoside is gradually eliminated as the plant matures have already been described in detail ("Bulletin of the Imperial Institute," 1903, **1.** 147). When dhurrin is decomposed by acids it yields prussic acid, glucose and *para*hydroxybenzaldehyde, the latter being an inodorous substance closely related to benzaldehyde (oil of bitter almonds). The enzyme which occurs in *Sorghum* along with dhurrin, is probably identical with the emulsin found in almonds. (Dunstan and Henry, "Proc. Roy. Soc.," 1902, **70.** 153.)

Phaseolunatin.

This new substance, there is reason to believe, is one of the most widely distributed cyanogenetic glucosides in nature, it having been isolated at the Imperial Institute from three different sources, the beans of *Phaseolus lunatus*, the roots of the cassava plant, and the stems, leaves, and seed of common flax. It also probably occurs in the leaves of the Para rubber-tree *Hevea brasiliensis*, and in several other plants from which, though the glucoside itself has not been isolated, its characteristic decomposition products have been obtained.

When decomposed by the general methods already described phaseolunatin yields prussic acid, glucose, and acetone. The three plants named contain in addition to the glucosides two enzymes, one either identical with or very similar to the emulsin of almonds, and the other closely resembling the maltase, which occurs in yeast, and it is to the action of this maltase-like enzyme that the natural decomposition of phaseolunatin, which takes place when the ground plants are moistened with water, is due. The chemistry of phaseolunatin and the enzymes associated with it have been dealt with in a paper communicated to the Royal Society (Dunstan and Henry, "Proc. Roy. Soc.," 1903, **72.** 285), and a fuller account of the enzymes was given in a paper read before the same society subsequently (*ibid.*, 1907, **79.** 315).

Beans of Phaseolus Lunatus.—Phaseolunatin was first prepared from the beans of this plant obtained from Mauritius, where it is grown in an almost wild state for use as a green manure. The same plant is also grown under practically wild conditions in Java, and it is from this source that the poisonous "Java beans," which have been imported recently into this and other European countries for use as a feeding material for cattle, are derived (*see* "Bulletin of the Imperial Institute," 1905, **3.** 373).

The beans obtained from *Phaseolus lunatus* as grown in Mauritius and Java possess a very characteristic shape, are somewhat shrivelled, and vary in colour from pale fawn with purple spots to deep almost purple black, though in the case of the "Java beans," but not in those obtained from Mauritius, a few pale cream-coloured beans are also present. Varieties of the same plant are grown in many tropical countries, especially in Burma. The beans produced by the varieties cultivated in the latter country differ markedly from the Java and Mauritius beans; in particular they are less angular in shape, smaller, more plump, and much lighter in colour, being almost white ("white Rangoon beans"), or pale pink or fawn with a few purple markings ("red Rangoon beans"). There exists yet a third variety of the beans of *Phaseolus lunatus* obtained from South America, Madagascar, and other tropical countries, and also produced to a small extent in the South of France. These beans are larger and plumper than the varieties already mentioned and are white, or nearly so. The last variety is generally known in commerce as "Lima beans."

Cordemoy has stated ("Flore de la Réunion," 1895) that the beans of *Phaseolus lunatus* are purple in the wild state, light brown when semi-cultivated and white when carefully cultivated. These three stages are roughly represented in the commercial products by the "Java" or "Mauritius beans," "Rangoon beans" and "Lima beans" respectively.

Owing to the recent large importation of "Java" beans into Europe, and the numerous cases of poisoning, which have resulted from the use of this material as a feeding-stuff, great interest has been aroused in this product, and the beans have been examined by many chemists in this country, Germany, France, Holland, and Belgium. Some reference has already been made in this "Bulletin" (1905, **3.** 373) to the results which have been obtained in this way, but since the date of that article further facts have been recorded. In a paper entitled "On the Presence and Detection of Cyanogen in Java, Burma and Haricot Beans," published in the "Analyst" (August, 1906), Messrs. Tatlock and Thomson give the results of a series of experiments they have made on the estimation of the prussic acid yielded by these various beans, and as the experience gained at the Imperial Institute with these products differs in some respects from that recorded by Messrs. Tatlock and Thomson, and also throws some light on points raised by those who took part in the discussion on their paper, it has been thought desirable to place these differences on record. In the first place it should be stated that the beans contain no amygdalin as Messrs. Tatlock and Thomson seem to suppose, but only the glucoside phaseolunatin already referred to. In the course of the discussion on Messrs.

Tatlock and Thomson's paper, Dr. J. W. Leather, Agricultural Chemist to the Government of India, stated that it is uncertain what the botanical nature of these beans is and that they seem to be derived from a mixture of species. Cordemoy's opinion, quoted above, seems to leave no doubt that these differently coloured beans are the product of a single species, and the French botanist Guignard has stated ("Comptes rendus," 1906, **147.** 545), that careful examination of "Java," "Rangoon," and "Lima" beans show that they all possess certain characters in common by means of which they may be distinguished from the beans yielded by other species of Phaseolus, and notably from common haricot beans derived from *Phaseolus vulgaris*. Guignard used for comparison with the commercial products an authentic sample of the beans of *Phaseolus lunatus* obtained from the Botanical Gardens at Buitenzorg. The Imperial Institute has received through the Government of India a sample of the beans of *Phaseolus lunatus* as grown in Burma, and comparison of these with the Burma, Rangoon, or Paigya beans of commerce, leaves little doubt that they are identical. Finally, the white "Lima beans" have long been a commercial article and are commonly cultivated in the South of France, and no doubt has been expressed as to their being the product of *Phaseolus lunatus*. There does not seem to be much ground for doubt as to the botanical origin of these beans. In this connection it is worth mentioning that several of the samples of Java beans examined at the Imperial Institute were found to contain a few seeds of *Dolichos lablab*, but the number of these present was always very small. No production of prussic acid could be detected in the admixed *Dolichos lablab* beans.

It is most desirable that confusion between the cultivated white beans of *Phaseolus lunatus* and ordinary haricot beans should not occur. The name haricot should be reserved for the beans derived from the well-known European species of *Phaseolus* furnishing this product. This unfortunate confusion of the white beans of *Phaseolus lunatus* with ordinary haricot beans is noticeable in Messrs. Tatlock and Thomson's paper, where the term haricot is apparently applied indiscriminately to white beans derived from *Phaseolus lunatus* or *Phaseolus vulgaris*.

It has been shown in the papers already referred to ("Proc. Roy. Soc.," 1903, **72.** 285; "Bulletin of the Imperial Institute," 1903, **1.** 15, 122, and 1905, **3.** 373), that the beans produced by *Phaseolus lunatus* grown under the practically wild conditions which obtain in Mauritius and in Java, yield much larger quantities of prussic acid than the semi-cultivated reddish beans produced in Burma, whilst the white Lima beans examined at the Imperial Institute yielded none. Correlating this with Cordemoy's statement quoted above, it has been suggested (*loc. cit.*) that the cyanogenetic principle appears to be more or less completely eliminated from the beans of *Phaseolus lunatus* by careful cultivation of the plant, since in the experiments made at the Imperial Institute, neither the white Rangoon nor the white Lima beans yielded any prussic acid.*

* *Compare, however, Henry and Auld, Journ. Soc. Chem. Ind., 1908,* **27,** *428.*

Beans of Phaseolus Lunatus.—Phaseolunatin was first prepared from the beans of this plant obtained from Mauritius, where it is grown in an almost wild state for use as a green manure. The same plant is also grown under practically wild conditions in Java, and it is from this source that the poisonous "Java beans," which have been imported recently into this and other European countries for use as a feeding material for cattle, are derived (*see* "Bulletin of the Imperial Institute," 1905, **3.** 373).

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Origin and colours of beans.	Dunstan and Henry.	Guignard.	Kohn-Abrest.	Tatlock and Thomson.
	Prussic acid.	Prussic acid.	Prussic acid.	Prussic acid.
Java—cont.	Per cent.	Per cent.	Per cent.	Per cent.
Cream white ...	0·105–0·110	0·052	0·037	0·027
Black with white stripes	0·062	—	0·058	—
Mauritius.				
Mixed, all colours ...	—	—	—	—
Purplish black ...	0·088	—	—	—
Brown	0·087	—	—	—
Light brown ...	0·041	—	—	—
Burma.				
Pale brown with purple spots	0·004–0·008	0·011	—	—
Cream white ...	Nil	0·006	—	—
Provence.				
Large cream white ...	Nil	traces 0·004–0·008	—	—
Madagascar.				
White	—	0·008	—	—

There is finally the question as to whether any simple process can be devised for rendering Java beans innocuous and suitable for use as fodder. It has been stated that the beans are rendered harmless by boiling, and that treated in this way they are commonly used in Java as food.

It has been found at the Imperial Institute that by soaking the beans in cold water overnight, and then boiling them in water until they are soft, practically no change in the amount of phaseolunatin takes place, but the cooked beans when broken up in water do not yield prussic acid, since the enzyme has been destroyed in the cooking process, and is no longer available to decompose the glucoside. Messrs. Tatlock and Thomson found, on the contrary, that in a sample of Java beans treated as described above the percentage of glucoside (measured by the amount of prussic acid produced) was reduced by about one-half.

It must be remembered that though such cooked beans no longer yield prussic acid when mixed with water, it does not follow that they are not poisonous, especially to herbivorous animals, since there is always the risk of the cooked beans being fed to the animals along with other vegetable material containing an enzyme capable of decomposing the phaseolunatin present in the cooked beans, even if there should be no intestinal enzyme capable of decomposing the glucoside.

It seems probable, however, that the whole of the prussic acid could be eliminated by grinding the beans to a fine powder, mixing this with cold water, and exposing it in thin layers, frequently stirred, to the air, but this scarcely seems to be a practicable process of treating the beans except on a very small scale.

Cassava.—The same glucoside phaseolunatin also occurs in the cassava or manioc, widely cultivated in the Tropics for the sake of its starchy roots, which are used as food, and also as a source of starch. Two varieties of cassava are known, viz., the "sweet" and "bitter" kinds. The presence of prussic acid in bitter cassava was first recorded by Boutron-Charlard in 1836, though the fact that the toxicity of this material was due to a volatile constituent was first established by Henry and Boutron-Charlard in 1833. Since that time it has generally been assumed that prussic acid is only obtainable from the "bitter" variety, but in 1870 Francis showed that both varieties as grown in the West Indies yield prussic acid in about the same proportions, and the production of the acid by both varieties has more recently been confirmed by Carmody and by Harrison. It was noticed in 1899 by Van Romburgh in Java that when the bruised leaves of the cassava plant are macerated in water, and the latter distilled, acetone and prussic acid are obtained. With a view to ascertaining the origin of the prussic acid in cassava, an examination of the tubers was undertaken at the Imperial Institute in 1905, and it was found possible to isolate from bitter cassava a glucoside, which was eventually proved to be identical with phaseolunatin obtained from *Phaseolus lunatus* (Dunstan, Henry, and Auld, "Proc. Roy. Soc.," 1906, B. **78**, 152). Further, it has also been shown that cassava contains the same mixture of enzymes as is present in the beans of *Phaseolus lunatus*.

Flax (Linseed).—The occurrence of cyanogenesis in flax was first observed by Jorissen in 1883, who stated that when linseed meal (ground flax seed) is allowed to stand with warm water at 25° C. prussic acid is produced. Subsequently the same author, in association with Hairs, succeeded in obtaining from flax seed a cyanogenetic glucoside, which was named linamarin. The quantity of this glucoside present in flax seed is exceedingly small, as is shown by the fact that the amount of prussic acid obtained from the seed is not more than 0·008 per cent. It seemed probable from a consideration of the results obtained by Jorissen and Hairs that linamarin might prove to be identical with phaseolunatin, and consequently the investigation of this material was undertaken at the Imperial Institute, with the result that it has been shown that the two glucosides are identical (Dunstan, Henry, and Auld, "Proc. Roy. Soc.," 1906, B. **78**. 145) and that further the same mixture of two enzymes, the one resembling emulsin and the other similar to maltase, as occurs in cassava and *Phaseolus lunatus*, is also present in flax.

Sambunigrin.

This glucoside was isolated from the leaves of the common elder by Bourquelot and Danjou in 1905, though Guignard had almost simultaneously recorded the presence in elder leaves of a cyanogenetic glucoside, which underwent decomposition by an enzyme also present in the leaves yielding prussic acid and benzaldehyde.

Prulaurasin.

This substance was obtained for the first time in a pure state from the leaves of the common cherry-laurel by Herissey, although various investigators had previously recorded the existence of a cyanogenetic glucoside in these leaves, and had obtained impure preparations of it, and, as already mentioned, the production of prussic acid when cherry-laurel leaves are crushed and moistened with water had been recorded as early as 1803. Prulaurasin is decomposed by dilute acids, and by the emulsin-like enzyme which occurs with it in cherry-laurel leaves yielding benzaldehyde (oil of bitter almonds), prussic acid, and glucose. It is of interest to note that amygdalin, sambunigrin, and prulaurasin all yield the same products when decomposed, but in the case of the first glucoside twice as much glucose is produced on hydrolysis as in the cases of the two latter substances. Sambunigrin has the same composition as prulaurasin, and in this connection it is worth mentioning that amygdalin is decomposed by the enzyme maltase, which occurs in yeast yielding a third glucoside, which has been named mandelic nitrile glucoside, and this also has the same empirical composition as prulaurasin and sambunigrin.

Gynocardin.

This cyanogenetic compound was isolated by Power and Gornall in 1904 from the oily seeds of *Gynocardia odorata*, and was subsequently examined in greater detail by Power and Lees. The raw material from which gynocardin was isolated is of special interest, since it was long supposed to be the source of chaulmugra oil, a material which has been used in the East for the treatment of leprosy, and has also acquired some reputation in European medicine as a remedy for some forms of skin disease. Investigations recently conducted in India have, however, shown that the real source of chaulmugra oil is the seed of *Taraktogenos Kurzii*, a material which curiously enough also contains a cyanogenetic compound, though this is of so unstable a character that it has not yet been possible to isolate it. When gynocardin is decomposed by acids or by an enzyme occurring with it in gynocardia seeds it furnishes glucose, prussic acid, and a third product, which is very unstable, and is immediately converted into an amorphous resin. The enzyme which occurs with gynocardin has been named gynocardase.

Karakin.

This substance was obtained by Easterfield and Aston in 1903 from the karaka fruit (*Corynocarpus laevigata*) of New Zealand. The production of prussic acid, which takes place in this fruit, has been traced to this glucoside, but practically nothing is known regarding the chemistry of the latter.

The cyanogenetic glucosides mentioned above are all that have been definitely isolated, though indications of the existence of such compounds in many other plants have been obtained, and it may with tolerable certainty be asserted that such compounds occur in all the plants in which cyanogenesis is known to take place.

It is, perhaps, of interest to mention that among the plants in which the production of prussic acid has been observed are included many which are of great economic importance. Reference has already been made in this connection to cassava, flax, bitter almonds, sorghum, and chaulmugra seeds, and in addition to these the acid has been obtained from the seeds and leaves of the Para rubber plant (*Hevea brasiliensis*), the leaves of *Hevea spruceana*, which also yields a marketable rubber, the seeds of two other Hevea species, the roots of the Ceara rubber plant (*Manihot Glaziovii*), a near relative of the cassava plant, the seeds, leaves, and flowers of numerous Rosaceous plants cultivated either for the sake of their fruits or flowers, the seeds of several species of Vicia used as feeding-stuffs, the seeds of *Schleichera trijuga*, from which "macassar oil" is obtained, alder-bark, employed to some extent in medicine, and recently Brünnich has observed its occurrence in small quantities in maize and other grasses grown in Queensland.

The Significance of Cyanogenesis.

In the literature relating to this subject three main ideas as to the significance of the production of prussic acid in plants may be traced. At first it was regarded as merely a waste product of no physiological importance; later the view that it was possibly a means of protection to the plant was suggested, and quite recently a small number of botanists and chemists have brought forward the idea that the acid is an intermediate product formed during the elaboration of proteins by plants. Evidence in favour of this last-mentioned view has been accumulated in several ways. In the first place Dr. Treub has investigated the distribution of cyanogenetic compounds in the two tropical plants *Pangium edule* and *Phaseolus lunatus*, and has determined the conditions which influence the production of the acids in these plants, and his results go to show that the acid must play some important part in their life processes.

Further, the number of plants in which cyanogenesis is known to occur is now comparatively large, and it is scarcely conceivable that there should be so many cases of the production of this acid unless this phenomenon is of some physiological significance.

Finally, the course of cyanogenesis has been investigated in several plants, and the results seem to indicate that the production of prussic acid is particularly active during that part of the life of a plant in which the vital processes are proceeding most actively. Thus in *Lotus arabicus*, *Sorghum vulgare*, and flax it

has been shown that the seed either contains no cyanogenetic glucoside or mere traces, and that on germination there is a sudden large development of cyanogenetic glucoside, which reaches a maximum usually before the plant is full grown, and then, as the period of ripening or complete maturation sets in, the amount of cyanogenetic glucoside declines, and finally disappears.

While it is probable, therefore, that cyanogenesis may play some important part in plant metabolism, it is not yet possible to say anything definite as to the method of the initial production of prussic acid, though various suggestions have been put forward to account for its formation in plants.

Since most plants derive their supply of nitrogen from soluble nitrates contained in the soil, it has been assumed that these nitrates form the primary source of the prussic acid. If it may be supposed that from the nitrates occurring in cell-sap, small quantities of free nitric acid may be generated by the action on the nitrates of vegetable acids, it seems likely that by the interaction of this free nitric acid, either with formaldehyde or sugar, prussic acid might be generated, and this might then combine on the one hand with a plant sugar and on the other with an aldehyde or a ketone occurring in the plant, forming a cyanogenetic glucoside of the usual type.

II. MISCELLANEOUS FOODSTUFFS.

Arrowroot.

Arrowroot is composed of nearly pure starch, together with a certain amount of moisture; it is obtained from the roots of a West Indian plant, *Maranta arundinacea*. Substances of a very similar nature are prepared from other plants such as *Tacca pinnatifida*.

Imports of Arrowroot into the United Kingdom in 1907.

	Weight.	Value.
Consigned from—	Tons.	£
British West Indies	1,422·4	35,208
Other British Possessions ...	17·3	770
Foreign Countries	4·7	259
Total	1,444·4	36,237

Imports of Starch and Farina into the United Kingdom in 1907.

	Weight.	Value.
Consigned from—	Tons.	£
British Possessions	46	1,141
Foreign Countries	75,127	893,784
Total	75,173	894,925

Imports of Potato Flour into the United Kingdom in 1907.

	Weight.	Value.
Consigned from—	Tons.	£
British Possessions	-	—
Foreign Countries	711	7,276

ARROWROOT FROM THE NORTHERN TERRITORY OF SOUTH AUSTRALIA.

This sample was said to be derived from plants of the Bermuda variety, *Maranta arundinacea*, which grow very freely in the Northern Territory of South Australia. On examination with the microscope, it was found to be composed of starch grains of the form characteristic of those of Bermuda arrowroot. It left only 0·13 per cent. of ash on ignition. From the results obtained it was considered to be of distinct commercial value. (March, 1904.)

TACCA ARROWROOT FROM THE EAST AFRICA PROTECTORATE.

This sample was a rather dull white powder, more gritty and less readily soluble in water than true arrowroot. When examined under the microscope it showed the usual characteristics of the starch from the root of *Tacca pinnatifida*. Tacca starch is a fairly well-known product, especially in the South Sea Islands, although it appears but rarely in European markets.

A portion of the sample was submitted to commercial experts, who stated that it would be readily saleable as a cheap manufacturing arrowroot at about 13*s*. 6*d*. to 14*s*. per cwt. As an arrowroot it would be considered rather poor, and it would compete with cheap grades of St. Vincent arrowroot. (October, 1905.)

STARCH PREPARED FROM THE BREAD-FRUIT TREE IN THE SEYCHELLES.

Two small samples of powder prepared from the bread-fruit tree were forwarded to the Imperial Institute by the Governor of Seychelles, with a request that a report upon their composition and commercial value should be furnished. It was stated that the samples were prepared in the island of Praslin, near Mahe, and a copy of a report by Dr. Denman, the Chief Medical Officer, upon a previous sample of the powder was enclosed. From the latter it appeared that the powder was practically pure starch.

The two specimens were labelled as follows:—

(I.) "*État naturel de la poudre*," and (II.) "*La même poudre tamisée*."

(I.) "*État naturel de la poudre*."

This specimen consisted of about 200 grams of a whitish powder, which exhibited a faint yellow tinge; it contained numerous small hard lumps, but these could be readily reduced to a fine powder. The sample possessed a slight odour, resembling that of arrowroot, and had a starchy taste.

(II.) "*La même poudre tamisée*."

This was a very fine whitish powder, which also exhibited a faint yellow tinge. It was perfectly free from lumps, possessed the same odour and taste as the preceding specimen, and closely resembled fine wheat flour in appearance. The sample weighed about 150 grams.

The results of the chemical examination of the two specimens, conducted in the Scientific and Technical Department of the Imperial Institute, were as follows:—

—	*État naturel de la poudre.*		*La même poudre tamisée.*	
	Sample as Received.	Calculated for Dry Material.	Sample as Received.	Calculated for Dry Material.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	17·09	—	17·13	—
Proteid	0·48	0·58	Nil	Nil
Fat	0·19	0·21	0·21	0·25
Starch	81·84	98·72	82·39	99·43
Sugar	Trace	Trace	Trace	Trace
Fibre	0·12	0·15	Trace	Trace
Ash	0·28	0·34	0·27	0·32
Phosphoric acid (P_2O_5), in ash	0·08	0·10	0·09	0·11

These analyses, confirmed by microscopical examination, show that the powders consist of practically pure starch, the percentages in the dry material being 98·7 and 99·4 respectively. Small amounts of ash and fat were present in both samples, the percentages being almost the same in each case, and in the unsifted sample there was 0·58 per cent. of proteid.

The specimen of the sifted powder was submitted for valuation to brokers in 1904, who were informed of the results of the chemical examination. So far as can be judged from the small sample available, they think that there would be a good demand for the material at about £7 per ton, c.i.f. London, but point out that a definite opinion cannot be expressed until a larger sample of about 10 lb. is submitted for practical trials. They state that it would not be advisable to forward consignments without an order, and that the material would have to be avail-

able in large quantities, say, from 100 to 200 tons at a time, before buyers would be disposed to take it up.

The present price of American powdered starch is about £8 10s. per ton in London, so that the value of the Seychelles product might improve as it became known on the market.

The preparation and use of Dried Potatoes.

Enquiries have been recently made concerning the preparation and use of dried potatoes in Great Britain. Particulars relating to this subject are not readily accessible, and it has been considered desirable, therefore, to publish ("Bulletin of the Imperial Institute," 1903, **1**. 77) the following summary of the information collected by the Imperial Institute with reference to the use of dried potatoes in this and other countries.

Dried vegetables and fruits are employed to a very much greater extent in Germany than in Great Britain, chiefly owing to the fact that supplies of fresh produce cannot be obtained there all the year round as in this country. Desiccated vegetables have become, in fact, a staple article of food in Germany, being regularly supplied to the army and navy, and they are also extensively employed in the mercantile marine and in the German colonies. With special reference to potatoes, it appears that in Germany one-half of the annual crop, which in 1901 amounted to 48,687,000 metric tons, is consumed directly as human food, and large quantities are also utilised for feeding stock. In these circumstances considerable attention has been devoted to the desiccation of potatoes, thereby enabling them to be stored without loss of nutritive properties for a much longer period than the raw produce, and during recent years great improvements have been effected in the desiccating process.

In America a considerable demand has also arisen for supplies of desiccated vegetables in the various mining districts, and consequently their manufacture has been commenced in Canada and the United States. A few years ago large samples of six different varieties, including potatoes, prepared in Ontario, were forwarded to the Imperial Institute, and were transmitted to the War Office for trial.

The forms in which dried potatoes are usually prepared are (1) slices and chips, and (2) granules or groats. The former variety does not appear to be prepared in Great Britain, although a quantity is imported in this form from Germany. The amount thus imported cannot be ascertained, however, as the different vegetables are not separately dealt with in the returns. The preparation of dried potatoes in this country is stated to be restricted to the granulated or groat variety, but these are only consumed to a very limited extent at home, being chiefly employed on board ship, or in countries where fresh potatoes are not readily obtainable, and also to some extent in the army and navy. The quantity prepared here cannot be definitely ascertained, but it is believed that, owing to the present facilities for preserving vegetables in a fresh condition, the production, which was never very large, is now steadily diminishing. Factories

for the preparation of dried potatoes and other vegetables exist in Essex, in Wigtownshire, and in Ireland.

The price of the granulated potatoes fluctuates with the cost of the raw material. It may be noted that 3 ozs. of the dried potatoes are equivalent to 1 lb. of the fresh vegetable.

When used for human food the dried potatoes are treated with a certain quantity of boiling water, allowed to stand for several minutes in a hot place, and then served as required. In addition to their use as a single vegetable, dried potatoes are also employed as one of the principal ingredients in the mixed vegetables which are largely utilised in a compressed form for military and other expeditions. A largely-used formula for such preparations is as follows:—

	Per cent.
Potato	40
Carrot	30
Cabbage	10
Turnip	10
Seasoning herbs (onion, leek, celery, parsley, parsnip, &c.)	10

Precise information concerning the methods employed in the preparation of dried vegetables, including potatoes, is not readily obtainable, as manufacturers are very reticent in supplying details regarding the processes they adopt. The following methods of desiccation have been employed for the purpose:—

1. Desiccation by a rapid current of dry air at the ordinary temperature.
2. Drying in hot-air chambers.
3. Drying in heated vacuum evaporators

Of these, the second and third have received most general application.

It is believed that most of the granulated potatoes prepared in this country are manufactured by Edwards' patented process. In the form of slices or chips dried potatoes are more easily prepared, and the product is stated to keep well. An outline of the process adopted is as follows—

After washing and peeling, the potatoes are cut into thin slices or strips and then placed in boiling water, to which some salt has been added, for five to seven minutes. After this treatment the potatoes are dried in chambers at a temperature of 200-212° F. (90-100° C.), the drying being completed in two or three hours. In working upon a large scale the boiling could be advantageously replaced by steaming, in which case the potatoes would probably be first steeped in water with a little salt.

The following description has been given of the process employed in the preparation of the compressed mixed vegetables already alluded to:—

"The vegetables are gathered in the autumn, when they are in their prime, and carefully sorted, then cleaned, washed, peeled, sliced, and slightly steamed. The various manipulations

were formerly performed by hand, but all are now done by machinery. The vegetables thus prepared are then dried in kilns and on lattice-work trays by currents of moderately hot, dry air, thereby retaining their natural colour, flavour, and aroma. This stage of the process requires the greatest care and attention, so as to keep the temperature constantly at the level as ascertained by experience to be necessary for each kind of vegetable. The vegetables and herbs are then carefully mixed in the proportions given above, and then compressed to one-eighth of their original bulk (when fresh) by powerful hydraulic pressure into moulds, thus forming square slabs about three-quarters of an inch thick, grooved so as to be divided into cakes of five rations each, at the rate of one ounce per ration, easily separated for convenience of issue. These slabs are then wrapped in paper and packed by machinery into square tins, which are hermetically soldered. Before the lid is soldered down a punch stamps it automatically from the inside with the season of manufacture. When two years appear on this stamp, as '1888-1889,' the first is the year of the crop and the second the year of compression. The tins are now made of bright 'coke' tin-plate of the best quality, it having been found by experience that the vegetables keep much better in this material than in the dull terne-plate formerly used."

The various operations involved in the desiccation of vegetables are nearly all performed by mechanical means. A large number of ingenious machines have been designed for peeling potatoes, apples, &c., and for cutting them into slices, chips, or shreds. These are chiefly of American origin, but are now largely manufactured in Germany also. With reference to drying machines, there are a considerable number upon the market at the present time. For use upon a small scale the "Ryder," an American machine, and the "Geisenheim evaporator," which, in its latest form, is known as the "Gnom (Waas patent) evaporator," appear to have met with general approval. The problem of devising a suitable machine for the desiccation of potatoes has not been entirely solved, however, and quite recently a competition has been opened in Germany, under the auspices of the Agricultural Department, the Alcohol Verein, and various agricultural societies, in which a series of prizes amounting to 30,000 marks is offered for the best potato-drying apparatus. The one condition imposed is that the machine or system shall be capable of desiccating potatoes so that they can be stored in a form suitable for stock feeding until the next year's crop is ready, and at a cost not exceeding $2\frac{1}{2}d.$ per centner (110 lb.). Twenty-two competitors have entered the competition, which should result in the production of a thoroughly suitable system for desiccating potatoes. As an indication of the scale upon which some of the different drying processes are worked in Germany, it may be mentioned that the "original Rassmus dryer" is guaranteed to dry 20 tons of potatoes, beets, beet-leaves, or other wet fodder in 24 hours. It is a vacuum evaporator which can be worked either with the exhaust steam from a high-pressure engine, or with steam direct from a boiler, according to circumstances.

BANANA PRODUCTS FROM THE SEYCHELLES.

Three samples of banana products were forwarded in June, 1905, in order that their commercial value in this country might be ascertained. They were labelled as follows:—

I. " Farine de bananes d'une teinte orange claire."

II. " ,, ,, ,, grise claire."

III. " Bananes séchées avec lesquelles sont produit la farine de teinte orange."

These products are prepared from bananas known locally as " bananes malgaches " and " bananes St. Jacques," both of which are stated to be peculiar to the Seychelles and to be forms of *Musa sapientum*, var. *paradisiaca*, Linn. Recently a third variety, " banane carré," which is resistant to weevils, has also been used.

The two specimens of flour, " orange " and " grey," were in the form of fine powder, and had evidently been carefully prepared. They possessed a faint agreeable aroma, which was practically identical in the two cases, but in point of colour and flavour the " orange " flour was distinctly superior.

Both specimens were submitted to chemical examination, and were found to have the following percentage composition:—

	I. "Orange."	II. "Grey."
Water	9·60	12·06
Proteid (calculated from total nitrogen)	3·00	4·80
Starch, &c. (by difference)	83·54	77·87
Sugar (glucose)	0·94	1·84
Fat	0·32	0·44
Fibre	0·79	0·70
Ash	1·81	2·29
Phosphoric acid, in flour	0·13	0·17

These results, which are in general agreement with previously recorded analyses of banana meal and flour, show that the material is relatively rich in carbohydrates and mineral matter (ash), but poor in proteid. Its nutritive value is therefore low, being much less than that of white wheaten flour, which usually contains from 8 to 11 per cent. of albuminoids, and also less than that of rice. Of the two samples under consideration the grey flour is distinctly superior to the " orange " in nutritive value, as it contains more proteid matter and also a higher percentage of phosphates.

Within recent years banana flour has been introduced into this country from the West Indies, and a limited demand for the product has been created. It is used, in conjunction with other materials, for the preparation of bread, invalid foods, and other dietetic specialities, and also to some extent in biscuit manufacture.

Samples of the two flours and of the dried bananas, from which the "orange" flour was prepared, were submitted for criticism and valuation to a manufacturer who has made a speciality of these products. After practical trials he reported that the "orange" flour possessed an excellent colour and flavour and would be very suitable for manufacturing purposes, as it could be utilised for all kinds of banana preparations. The "grey" flour, although of higher nutritive value than the "orange," was less satisfactory in colour and flavour, and its use would be restricted to those preparations in which its dull colour would not be objectionable. He valued the "orange" flour at 20*s*. per hundredweight, the "grey" at 16*s*. per hundredweight, and the dried bananas at 18*s*. per hundredweight delivered in London.

He stated that in his opinion it will probably be found most advantageous to export the dried bananas rather than the flour, as the manufacturer could grind and dress the flour to suit his particular purpose, and thus ensure absolute uniformity of the product. One of the great obstacles to the use of banana flour at the present time is the extreme variation in character which is frequently exhibited by commercial consignments from the same source, and this fact militates against its regular use for many purposes.

Great care has to be exercised in the preparation of the dried bananas in order that the colour and flavour of the flour may always be the same. The best time to collect bananas required for the preparation of flour is said to be when the skin is just turning colour. In the Seychelles special apparatus for drying bananas has been erected in which the fruits are dried in about 18 hours at a temperature not exceeding 65° to 70° C. Ten tons of dried bananas were exported in 1906 and it was expected that 50 tons would be produced in 1907.

Samples of preserved plantains and of a coffee substitute prepared from bananas have also been received from the Seychelles for examination, but inquiry shows that neither of these products is likely to find any considerable market in the United Kingdom.

HONEY.

Imports of Honey into the United Kingdom in 1907.

Consigned from—	Weight. Tons.	Value. £
British West India Islands	634	14,977
Other British Possessions	32	1,042
Foreign Countries	528	15,910
Total	1,194	31,929

HONEY FROM TRINIDAD.

This honey, which was received in March, 1904, for examination and valuation, had been prepared by Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad; it was pre-

duced by Italian bees at the Experiment Station during the season when the logwood trees were in flower. Such honey is stated to be very highly esteemed in Trinidad, and it was desired to ascertain whether this opinion would be confirmed in this country.

The sample was a viscous liquid of sherry-brown colour, and was almost perfectly clear. It possessed an excellent flavour and aroma. On chemical examination it furnished the following results:—

	Per cent.
Moisture (110° C.)	16·5
Reducing sugars (calculated as dextrose) ...	80·7
Non-reducing sugars (calculated as sucrose) ...	2·4
Mineral matter (ash)	0·24
Insoluble matter	Trace.
Specific gravity at 15·5° C.	1·429
Rotation of 10 per cent. solution in 20 cm. tube at 20° C.	−2·5°

The composition of honey is liable to considerable variation, but the above figures correspond generally with those furnished by the majority of samples of genuine honey, in which the moisture generally ranges from 17 to 20 per cent., the total dextrose from 70 to 80 per cent., the ash from 0·10 to 0·25 per cent. and the specific gravity from 1·415 to 1·429.

The brokers to whom the sample was submitted reported that it was of fair colour, clear, and would be worth about 20*s*. per cwt. in the London market, at which price they anticipate there would be a fair demand. For comparison with this valuation the current London prices for other varieties of honey may be quoted:—

	Per cwt.
	s. *s*.
Chilian	18 to 30
Californian	20 „ 40
Jamaican	16 „ 27

"Ninkon" and "Mfrinkon" Fruits and "Inkon" Leaves from Southern Nigeria.

A sample of "Ninkon" fruits was forwarded by the Secretary at Calabar in 1905. It was stated that these fruits are employed by the natives for sweetening liquids and as a sweetmeat. The fruit is cut and the seed is pushed out with the jelly adhering to it. If used as a sweetmeat the jelly is sucked off and the seed thrown away; if for sweetening liquids the seed with the adhering jelly is put into the liquid, and when the jelly has dissolved off the seed is taken out and thrown away. The thick skin and seed are both useless.

The sample consisted of irregularly triangular-shaped brownish fruits having a curious ammoniacal odour. Each fruit con-

tained three brown seeds which were very hard and rough-coated. The seeds were starchy but did not appear to contain oil; they were surrounded by a shining brown layer which swelled and gelatinised on moistening with water, but was not sweet as was stated to be the case in the fresh fruits. At the base of each seed a quantity of softer, brownish-black substance occurred, which, in some cases, but not invariably, possessed a very sweet taste somewhat resembling liquorice. This substance was carefully removed from the seeds and submitted to examination in order to determine if possible the constituent to which the sweetness is due.

The results of the examination indicated that no sugars were present, and no substance resembling glycyrrhizin, to which the sweet taste of liquorice is due, could be detected.

The amount of the sweet brownish substance obtained from the fruits was insufficient for further investigation.

It would appear that the mucilaginous substance surrounding the seeds becomes hard and insoluble as the fruits dry and loses its peculiar sweetness. The fruits are unlikely to be of any value for export.

In addition to the above sample, three herbarium specimens of the "Ninkon" and allied plants were forwarded by the Curator of the Botanic Station at Calabar in 1906, who supplied the following information.

Specimen No. 1. "*Ninkon*" (Female).—"Fruit produced from root and slightly buried, triangular, outer coat bright red, generally 3-celled, containing three black, hard seeds, surrounded by jelly-like substance. Seeds are sucked by the natives, who call them 'Ninkon.' This plant is called the Female."

Specimen No. 2. "*Mfrinkon*" (Male).—"Fruit produced in clusters from stem just under the leaf. Round, bright red, generally 3-celled, three black seeds surrounded by a similar jelly, but is not eaten or sucked as No. 1. This plant is called by natives 'Mfrinkon' and Male."

Specimen No. 3. "*Inkon*" (Leaf).—"Neither flowers nor fruits were available. Specimen sent owing to its similarity to No. 1 and 2. This plant is called 'Inkon' and 'Leaf' by the natives, who say it never has flower nor fruit."

These three specimens have been identified at Kew as follows:—

No. 1. "Ninkon" (Female), *Thaumatococcus Daniellii*, Benth.

No. 2. "Mfrinkon" (Male), *Sarcophrynium macrostachyum*, K. Schum.

No. 3. "Inkon" (Leaf), *Sarcophrynium* sp.

The sweetness of the fruits of *Thaumatococcus Daniellii* has been previously recorded, and it has been stated that they were commonly used by the natives in Sierra Leone for sweetening purposes

AUSTRALIAN GRASS TREE OR "BLACKBOY," *Xanthorrhœa Preissii.*

The trunk of this tree is composed of a fibrous core surrounded by a thick layer of material of quite a different nature, being composed of leaf bases closely packed together. The fibrous core, when extracted with water, yields a sweet liquid, and an examination of its composition was made at the suggestion of the Agent-General of Western Australia. It was thought that it might be capable of utilisation as a cattle food, or for the manufacture of glucose or alcohol. The results are given below, together with those published by E. A. Mann (Jl. Soc. Chem., Industry, 1906, 25, 1076) for comparison.

—	Moist core from a trunk in the Imperial Institute Collections.		A fodder prepared from the interior core. E. A. Mann's Analysis.	
	Composition per cent.		Composition per cent.	
	Moist core.	The same water-free.	The fodder.	The same water-free.
Water	54·0	—	9·19	—
Albuminoids	0·87	1·9	2·83	3·1
Fat	0·16	0·35	0·78	0·86
Carbohydrates, &c., by difference	23·57	51·75	50·87	56·0
Fibre	19·1	41·0	35·93	39·6
Ash	2·3	5·0	0·40	0·44
	100·00	100·00	100·00	100·00
Carbohydrates, &c.—	Approximately only			
Reducing sugars calculated as dextrose ...	5·0	11·0	10·25	11·3
Non-reducing sugars calculated as cane sugar	10·0	21·8	15·86	17·5
Other Carbohydrates, &c., by difference ...	8·57	18·95	24·76	27·2
	23·57	51·75	50·87	56·0
Substances extracted by hot water	17·3	37·0	—	—

In the analysis of the moist core the estimation of the sugars was made with an alcoholic instead of an aqueous extract, as the latter was found to contain a substance of unknown reducing power which, if calculated as dextrose, led to inaccurate results. Attempts were made to isolate cane sugar by crystallisation, but without success. Only minute traces of starch were detected microscopically.

As a feedingstuff, the material is only comparable with hay, and even then it is poor in albuminoids; the fibre, too, owing to its woody nature might prove unsuitable, and the effect on

stock would have to be carefully watched. The material might be used for the production of glucose and alcohol, but the manufacture is unlikely to prove remunerative in view of the low price of glucose syrup, made from starch of poor quality, large quantities of which are available for the purpose.

Canadian Cider.

Two samples of Canadian cider, each of about a pint, were forwarded with the object of ascertaining their composition for comparison with that of typical brands of English cider, and of determining, if possible, the causes of the inferiority of the Canadian product. It was stated that they probably represented the best commercial refined cider, such as is sold to the trade in Canada.

The cider was a bright yellow colour and clear, but each bottle contained a slight sediment. It had a slightly sour fruity odour and a sweet unpalatable taste. Only a very few bubbles of gas escaped when the bottles were opened, so that the cider was practically quite flat on arrival. Both specimens rapidly deteriorated on keeping, after a portion of the liquid had been removed from the bottles for analysis, notwithstanding the fact that a trace of salicylic acid was found to have been added as a preservative, and that the bottles were stored in a cool place. In one case, No. I., the liquid had become quite turbid by the second day, and further fermentation, accompanied by the development of considerable pressure in the bottle, was evidently taking place. The other sample showed similar behaviour, but the change did not occur quite so rapidly. A microscopical examination of the turbid liquids showed the presence of numerous yeast cells.

An analysis of each sample was made and furnished the following results, for comparison with which a number of analyses of typical English and American ciders have been summarised:—

Analyses of Ciders.

Authority for analysis.	Name of cider.	Specific gravity at 15·5° C.	Alcohol per cent. by weight.	Cane sugar.	Glucose.	Volatile acid as acetic.	Fixed acid as malic.	Extract.	Ash.	Remarks.
				Calculated in grammes per 100 c.cm						
Scientific and Technical Department, Imperial Institute.	The refined cider from Canada :—									Found to contain a trace of Salicylic acid.
	I.	1·0370	2·97	1·95	6·82	0·04	0·58	10·60	0·20	
	II.	1·0359	3·10	1·08	8·25	0·08	0·57	10·36	0·22	
Allen, A. H.... ...	Norfolk bottled cider (6 samples) :—									
	Average	1·007	6·86	—	2·44	0·12	0·38	3·61	0·29	
	Maximum	1·012	7·69	—	4·55	0·21	0·42	5·47	0·33	
	Minimum	1·002	5·30	—	0·77	0·07	0·31	2·07	0·26	
Allen, A. H.... ...	English draught cider (5 samples) :—									
	Average	1·018	3·75	—	3·55	0·19	0·29	5·29	0·28	
	Maximum	1·027	4·37	—	6·17	0·23	0·43	8·14	0·35	
...	Minimum	1·006	2·49	—	0·93	0·16	0·20	2·59	0·22	
Allen, A. H.... ...	Devonshire bottled ciders (11 samples) :—									
	Average	1·020	4·26	—	4·25	0·26	0·26	5·47	0·30	
	Maximum	1·032	5·39	—	7·24	0·37	0·35	8·23	0·41	
	Minimum	1·003	2·57	—	0·94	0·19	0·12	2·12	0·23	

Analyses of Ciders—cont.

Authority for analysis.	Name of cider.	Specific gravity at 15·5° C.	Alcohol per cent. by weight.	Cane sugar.	Glucose.	Volatile acid as acetic.	Fixed acid as malic.	Extract.	Ash.	Remarks.
			Calculated in grammes per 100 c.cm.							
Embrey, G.	American ciders (3 samples):—									
	Average	1·0333	2·95	—	7·68	0·090	0·571	9·25	0·28	
	Maximum	1·0342	3·49	—	8·20	0·128	0·712	9·60	0·32	
	Minimum	1·0323	2·45	—	6·93	0·048	0·330	8·96	0·24	
Paris Laboratory ...	French ciders (8 samples):—									
	Average	Not given in any case.	2·97	—	1·90	Not given in any case.	0·365*	5·73	0·28	*Result is *total* acid calculated as H_2SO_4 (Sulphuric acid).
	Maximum		4·74	—	3·90		0·536*	8·12	0·35	
	Minimum		0·79	—	0·37		0·205*	2·09	0·23	
United States Department of Agriculture.	American "dry" or well-fermented ciders (7 samples):—									
	Average	1·0154	5·17	—	—	—	0·402*	3·88	0·37	*Total acid as malic.
	Maximum	1·0306	8·09	—	—	—	0·602*	5·92	0·50	
	Minimum	1·0003	3·63	—	—	—	0·113*	1·80	0·27	
United States Department of Agriculture.	American "sweet" or incompletely fermented ciders (6 samples):—									
	Average	1·0455	1·40	—	—	—	0·405*	8·17	0·32	*Total acid as malic.
	Maximum	1·0552	3·46	—	—	—	0·565*	9·75	0·37	
	Minimum	1·0203	0·20	—	—	—	0·302*	3·84	0·27	

From a comparison of these figures it will be seen that the specimens of Canadian cider under examination correspond, generally, with the samples prepared in the United States in having a higher specific gravity, and containing a smaller proportion of alcohol and a larger amount of sugar than the majority of English ciders. These features have been stated to be characteristic of the United States product, in the manufacture of which inferior and surplus table apples are utilised. In England and France it is considered that cider possessing good colour, flavour, and keeping properties can only be prepared from particular varieties of apples, which are too bitter and too small for table use, and these are specially cultivated for the purpose. In consequence of this variation in procedure, the United States cider is a product entirely differing from the English beverage, and possessing none of the distinctive qualities of the latter. On account of its sweetness and low alcoholic strength, it requires to be sterilised before exportation, and it is artificially carbonated on arrival in this country.

The quantity of cider and perry imported into the United Kingdom from the United States has fluctuated considerably during recent years, as shown by the following figures:—

1898 ...	... 303,477	gallons	valued at	£10,093
1899 ...	... 373,585	,,	,,	£13,173
1900 ...	... 421,865	,,	,,	£14,937
1901 ...	... 331,247	,,	,,	£11,884
1902 ...	... 187,260	,,	,,	£6,978

The declared value of United States cider is therefore from *8d.* to *9d.* per gallon, whereas that of the cider imported from France is from *1s.* to *1s. 2d.* per gallon.

No information has been supplied regarding the kind of apples used or the methods of manufacture followed in the case of the samples of Canadian cider submitted for examination, but from the amount of sugar present in the product it would appear that sweet apples were employed. The character of the cider therefore approximates to that prepared in the United States, and for the reasons indicated above, it is totally different from that produced in this country. In its present form it might serve as a substitute for some of the United States product, but it could not compete with English cider.

If it be desired to produce a cider similar to the English beverage, it will be necessary to employ special varieties of apples and to imitate the improved methods of manufacture now employed in this country. (January, 1904.)

Coconut "Water."

A sample of this material was sent by the Secretary of the Ceylon Committee for the St. Louis Exhibition with the view of ascertaining whether sugar could be profitably extracted from this material in Ceylon, where it is at present a waste product in the process of preparing coprah.

The sample of the "water" measured two gallons, and consisted of a thin, slightly opalescent liquid which had a strong odour of chloroform, the latter having been added to prevent fermentation during transit.

The composition was determined with the following results:—

	Per cent.
Saccharine constituents:—	
Mannitol (approximately)	1·8
Cane sugar	0·1
Glucose	0·9
Acid constituents:—	
Volatile acid (calculated as acetic acid)	0·07
Non-volatile acid (calculated as tartaric acid)	0·41
Mineral matter (ash)	0·50
Water	96·00

There are a number of previous analyses of coconut "water" on record, with which the foregoing results may be compared. According to J. Lepine ("All about Cocoanut Planting," A. M. and J. Ferguson, Colombo, 1904), Bizio has stated that the "water" and the kernel of the coconut "contain no sugar but mannitol." Lepine does not give a reference to Bizio's paper in which this statement occurs, and, consequently, it has been impossible to verify it. Two papers by Bizio, on the subject of the composition of coconut "water," are published in the Ann. Sci. Lomb. Veneto (iii., 1833, pp. 1-16 and pp. 107-120), but in these there is no reference to mannitol, the only sweet constituent found being a substance which is named "glycina," and the reactions of this are not identical with those of mannitol. According to Lepine (*loc. cit.*) the sugar present in both the kernel and the water of the coconut is ordinary cane-sugar.

More recently, Van Slyke ("American Chemical Journal," 1891, 13 pp. 130-131), has found 3·9 per cent. of glucose and a trace of cane-sugar in the "water" of unripe coconuts, and 4·42 per cent. of cane-sugar and a trace of glucose in the "water" of ripe nuts, whence it would appear that during the ripening process, the glucose in the coconut "water" is largely converted into cane-sugar. Van Slyke found no mannitol in the "water" from either ripe or unripe nuts.

As the results obtained in the examination of the present sample of Ceylon coconut "water" were not in harmony with those of Van Slyke, it was thought advisable to examine a sample of "water" from ripe coconuts as imported into the United Kingdom. This gave the following results:—

	Per cent.
Saccharine constituents:—	
Cane-sugar	2·6
Glucose	0·5
Mannitol	Nil.
Other organic matter...	1·1
Mineral constituents (ash)	0·5
Water	95·3

These results agree fairly well with those recorded by Van Slyke for the "water" of ripe coconuts. The present sample of water from Ceylon coconuts appears therefore to be abnormal in containing mannitol in place of almost the whole of the glucose and cane sugar usually present. It would be interesting to know whether this replacement of glucose and cane sugar by mannitol constantly occurs in nuts grown in Ceylon, or whether it is characteristic of a particular variety of nut.

It is worth notice that mannitol is very closely related to glucose, and that it is possible that the presence of mannitol in this sample of "water" may be due to a change similar in character to the "mannitol fermentation," which occasionally takes place in wine, whereby the sugars normally present in the wine are partially converted into mannitol.

It is clear from the foregoing results that it would be impossible to manufacture sugar from coconut "water" as represented by this sample, since it contains only 0·1 per cent. of cane-sugar. Further, it is highly improbable that sugar could be manufactured at a profit from coconut "water" even when this contains the whole of its saccharine contents in the form of cane-sugar. Van Slyke found in the richest sample of coconut "water" he examined 4·43 per cent. of cane-sugar, which was associated with 3·15 per cent. of non-saccharine organic matter and 1·06 per cent. of ash. The crude juice expressed from the sugar cane contains, as a rule, nearly 20 per cent. of cane-sugar, and not more than 0·5 per cent. of non-saccharine, organic matter, and about 0·25 per cent. of ash.

Coconut "water" therefore contains at the most only about one-fifth the amount of sugar present in the juice of the sugar cane, and as the cost of extraction would be much greater than from the sugar cane there seems little likelihood that the "water" could be successfully utilised as a raw material for sugar manufacture, even though it is at present a waste product in Ceylon. (March, 1906.)

Yebb or Yeheb Nuts from Somaliland.

A sample of these nuts, weighing 18 lb., was forwarded in 1905 to the Imperial Institute by Colonel E. J. E. Swayne, H.M. Commissioner of the Somaliland Protectorate, in order that their nutritive value might be determined, and a second sample was sent by him in 1906.

These nuts are of special interest, as they have formed the principal food of thousands of destitute refugees, and grow in the arid "Haud" at Damot and along the southern border.

The kernels of most of the nuts of the first consignment were found to be decomposed, and when cut open presented a black appearance, whereas the good kernels were white or yellow.

An analysis of the selected kernels gave the following results:—

	Per cent.
Moisture	9·3
Albuminoids	11·8
Amides, &c.	1·3

		Per cent.
Oil	...	10·8
Sugars	Reducing ...	2·3
	Cane ...	21·6
Carbohydrates (other than sugars); by difference		37·1
Fibre	...	2·7
Ash ...	...	3·1
Nutrient ratio	...	1: 6·5
Nutrient value	...	92

The nuts were tested for alkaloids, and cyanogenetic glucosides, but no indication of the presence of such constituents was obtained.

The results of the analysis indicate that the nuts are likely to prove a useful foodstuff. A satisfactory point is the presence of considerable quantities of sugars and oil in addition to the carbohydrates.

Judging from the analytical figures alone, the nutrient ratio, *i.e.*, the ratio of albuminoids to carbohydrates and oil converted into their starch equivalents, is a very serviceable one, and the total "nutrient value" is high. The kernels are rather tough, and this point raises some doubt as to the complete digestibility of the carbohydrates other than sugars.

In preparing the nuts for use as a food, it is desirable that they should be soaked in just such a quantity of water as they can absorb, since if more be used there is danger of loss of the sugars, which would diffuse into the excess of water.

The identity of the plant producing these nuts could not at first be determined at Kew, but additional material having been received there from Somaliland through the present Commissioner, Captain H. E. S. Cordeaux, it proves to belong to the order Leguminosæ, and represents a hitherto unknown genus, which has been named Cordeauxia.

The plant has been described as *Cordeauxia edulis*, Hemsley ("Kew Bulletin," 1907, p. 361, and Hooker's "Icones Plantarum," xxix. tt. 2838, 2839).

Considerable interest attaches to these nuts on account of their high nutritive value as a food. It is desirable that the cultivation of this plant should be tried in other countries, especially where a foodstuff is needed which can be grown in arid places, as appears to be the case with this plant in Somaliland.

III.—TEA, COFFEE, COCOA, &c.

Certain vegetable products are used as articles of diet, not to provide nourishment to meet the demands of the body for waste-repairers and for sources of energy, but chiefly for the stimulating action they have on the brain and nervous system; these products

contain the substance *caffeine*, or the closely allied substance *theobromine*, together with small quantities of volatile oils, which impart a pleasant flavour, and perhaps take part in the stimulation.

The best known of these products are tea, coffee, and cocoa. The first two contain caffeine, and the third contains theobromine, together with a much smaller proportion of caffeine. Cocoa as usually prepared for use contains also an appreciable amount of nutrients. Besides these there is the kola " nut," the produce of a West African tree; it is not really a nut, but a large seed taken out of a pod. It is much valued by the natives of the West Coast of Africa, who chew the fresh seeds. These seeds contain caffeine, together with a very small proportion of theobromine. A certain amount of kola nuts, both fresh and dried, are imported into Europe, but the high price the natives are willing to pay for the fresh nuts renders it unlikely that this import will increase to any extent.

Various samples of these products have been received for examination, and reports on them are given in the following pages, together with some tables of statistics showing the magnitude of the trade in these articles of commerce. An account is also given of " Ranawara tea," which is used in Ceylon as a stimulant.

TEA.

Imports of Tea into the United Kingdom in 1907.

Consigned from—	Weight. Tons.	Value. £
British India	76,604	5,752,918
Ceylon and Dependencies	47,951	3,608,616
Natal	257	17,107
British West Indies	1¼	100
Other British Possessions	48	3,782
China and Hong Kong	8,639	782,916
Java and the Netherlands	7,453	529,216
Other Foreign Countries	622	50,064
Total	141,575¼	10,744,719

TEAS FROM THE NYASALAND PROTECTORATE.

Six samples of tea were included in a collection of vegetable products which was forwarded to the Imperial Institute from British Central Africa by His Majesty's Acting Deputy Commissioner and Consul, together with a descriptive report, compiled by the Head of the Scientific Department, Zomba, giving an account of the origin and production of the materials included in the collection. Such of the products as appeared to be of special interest were chemically examined, and were submitted to brokers and to technical experts for commercial valuation.

The samples of tea forwarded were of very good quality; they contained from 3·08 to 3·68 per cent. of caffeine, which is about

equal to that contained in Indian teas. It was impossible, unfortunately, to judge of the aroma of these teas owing to their having absorbed the odour of tobacco along with which they had been packed. They were valued at from 5¼*d.* per lb. for dust "fannings" to 7½*d.* per lb. for "orange pekoe." It is probable that teas grown in British Central Africa would be readily saleable, and in view of the fact that the consumption of tea is extending rapidly on the European continent, the cultivation of this product might well be extended in the Protectorate. In this connection it may be mentioned that there is a large demand for green tea in the United States, which is at present almost entirely supplied from China and Japan, although of late a fair quantity of Ceylon green tea has also been sold there. It might be worth while, therefore, for planters in British Central Africa to endeavour to produce a green tea suitable for the American market, since this would probably prove more remunerative than the manufacture of black teas to be sold in competition with the Indian and Ceylon products.

The six samples were grown at Mlanje, and were prepared without the aid of machinery. The results of the chemical examination are given in the following table:—

No.	Description.	Moisture.	Ash.	Caffeine.	Tannin determined by Eder's method.	Soluble Extract.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	"Orange ...	8·26	5·03	3·68	10·5	26·5
4	Pekoe" ...	7·84	5·28	3·54	10·4	25·4
2	"Broken ...	8·32	5·09	3·35	9·5	23·7
6	Mixed" ...	7·77	5·60	3·22	9·8	23·0
3	"Dust ...	8·58	5·20	3·08	10·3	29·6
5	Fannings"...	8·43	5·17	3·19	10·6	28·8

These results show that the samples of tea are of good quality. The percentages of ash and soluble extract are, however, somewhat lower than those yielded by the best Indian and Chinese teas.

A leading firm of brokers to which they were submitted for commercial valuation reported that the value of the teas could only be judged from their appearance since, as has been already stated, their flavour was masked by that of tobacco. The infused leaves were moderately bright, and, in the two "Broken Mixed" and the two "Orange Pekoes," the leaf appeared to have been fairly well manipulated, and contained a small quantity of tips. The following values were assigned to the samples:—

			Per lb.
No. 1. ...	"Orange Pekoe," ...	about	7*d.*
No. 4. ...	" " ...	"	7½*d.*
No. 2. ...	"Broken mixed," ...	"	6½*d.* to 6¾*d.*
No. 6. ...	" ...	"	7*d.* to 7¼*d.*
No. 3. ...	"Dust fannings," ...	"	5¼*d.*
No. 5. ...	" ...	"	5¼*d.*

TEA FROM HONG KONG.

This sample of tea was grown by the Chinese in the village of Tin Tso Ngam, in the new territory of Hong Kong, at an elevation of 1,000 feet above the sea.

It consisted of about 10½ oz. of leaves enclosed in a hermetically sealed tin. The leaves were dry and brittle, did not appear to have been rolled, and varied in colour from greenish-yellow to nearly black. A small proportion of hard, dry, greenish-brown flower buds was present among the leaves. The tea possessed a peculiar, sweet, but not altogether pleasant aroma, and did not seem to have undergone the process of fermentation. A careful examination of the sample showed that no leaves other than those of genuine tea were present.

The results of the chemical examination of this tea are given in the following table, and are compared with the results yielded by eight samples of black China tea previously examined in the Imperial Institute. The tannin was estimated by a modification of Löwenthal's method. The amount of soluble extract was determined by infusing the tea in 100 times its weight of boiling water, allowing it to stand for ten minutes and afterwards evaporating the liquid to dryness and weighing the residue.

—	Tea from Hong Kong.	8 samples of Black China Tea. Average results.	Maximum results.	Minimum results.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8·4	8·2	9·2	7·1
	Calculated on the dry tea.			
Ash	5·6	6·8	8·2	6·0
Caffeine	2·6	3·0	3·7	2·57
Tannin	11·0	5·1	9·3	3·3
Soluble Extract ...	30·2	24·3	27·2	19·0

These figures show that the percentages of moisture, ash, and caffeine in the Hong Kong tea are about normal. The amounts of soluble extract and tannin, however, are both above the average, and this is probably due to the fact that the leaves had not undergone fermentation.

The commercial experts to whom it was submitted for commercial valuation reported that the tea apparently had not been subjected to the ordinary processes of manufacture, and was, therefore, unsuitable for the English market. The leaves appeared to have been merely dried without having been submitted to any fermentation. As no rolling had been done the tea had a very rough appearance, the leaf being open and irregular. The infusion was found to possess fair pungency, but was of somewhat coarse flavour and very pale colour. It was stated that as the tea is unsuited to the market it was difficult to place any value on it, but the opinion was expressed that it

might perhaps realise 1*d*. or 2*d*. per lb., although if properly manufactured it would, of course, be of considerably greater value.

It is evident from the results of this enquiry that the tea is of satisfactory growth, but is of little value in the English market owing to its not having been subjected to the usual manufacturing processes. There seems, however, no reason to doubt that if the tea were properly prepared it would be of commercial value, and it seems advisable that the service of some skilled Chinese from the tea districts should be secured for this purpose. (March, 1906).

TEAS FROM NATAL.

The introduction of tea into Natal took place in 1877, when seed was forwarded from Calcutta and was planted as soon as it arrived. The varieties introduced were "Assam Indigenous" from the Rookang Estate, and "Assam Hybrid" from the Longeeburr Estate. The former has been found to be the more suitable, as it produces more leaf and yields a manufactured tea of superior quality. After various disappointments and discouragements, owing to losses caused by drought and the attack of insect pests, no serious attempt was made to extend the cultivation until 1881. Since this time the area under cultivation has gradually increased; in 1907 it amounted to 5,226 acres and yielded 1,324 tons.

The following table shows the growth of the industry:—

Area of Land under Tea Cultivation and quantity produced in Natal.

Year.	Area. Acres.	Production. Tons.
1880	8	Not shown.
1883	149	"
1888	801	59
1893	1,883	257
1898	2,667	463
1900	4,162	750
1901	4,107	768
1902	3,542	802

In the Colony the industry is protected by a duty of 4*d*. per lb. on imported tea. Natal tea also finds a free market in Cape Colony, the Transvaal, and in the Orange River Colony, consequently very little of it is exported from South Africa, as remunerative markets are close at hand.

The samples of Natal tea which are the subject of this report were taken from specimens exhibited in the Natal Court of the Imperial Institute and from supplies forwarded to the South African Products Exhibition of 1907 in London. The latter specimens were transferred to the Imperial Institute at the close of the Exhibition, and are now shown with other samples in the Natal Court.

At the request of the Natal Government a chemical examination of representative samples has been carried out in order that a comparison of Natal teas with Indian and China teas could be made.

The results of the examination are shown in the following table, which includes for comparison the corresponding figures obtained at the Imperial Institute for Indian and China teas and also for Ceylon green teas:—

Estate.	Description.	Moisture.	Percentages calculated on material dried at 100° C.			
			Ash.	Extract.†	Caffeine.	"Tannin."‡
Natal Teas—						
Kearsney ...	Grade 1* ...	9·1	5·8	26·1	3·9	7·8
" ...	Grade 2* ...	7·6	5·6	28·8	3·6	6·3
" ...	Grade 3* ...	7·4	5·2	27·4	3·1	6·7
" ...	Grade 4* ...	8·7	5·9	25·0	3·4	6·8
" ...	Flowery Pekoe	7·6	5·1	not determined		7·0
" ...	Broken Pekoe	6·9	5·8	not determined		7·3
Barnsdale ...	Pekoe ...	5·96	5·8	26·2	4·8	10·5
Clifton ...	Pekoe ...	6·2	4·8	31·4	not determined.	13·0
Barnsdale ...	Golden Pekoe	5·5	5·5	28·0	4·4	11·5
" ...	Flowery Pekoe	6·1	5·3	27·0	4·2	11·6
Aroma ...	Pekoe Souchong.	7·1	5·5	24·3	4·0	10·4
" ...	Fine Natal Souchong.	8·0	5·0	20·9	4·1	10·1
Barrow Green	Choicest Golden Pekoe.	7·7	5·2	33·0	4·4	10·8
	Average ...	7·1	5·4	27·1	4·0	9·2
Indian Teas (13 samples).	Maximum ...	7·8	6·9	35·2	4·1	11·1
	Minimum ...	6·4	5·4	27·4	3·6	6·9
	Average ...	7·1	6·0	31·7	3·8	9·2
China Teas (8 samples).	Maximum ...	9·2	8·2	27·2	3·7	9·3
	Minimum ...	7·1	6·0	19·0	2·6	3·3
	Average ...	8·2	6·8	24·3	3·0	5·2
Ceylon Green Tea.	No. 1	6·7	2·6	24·5	2·9	14·5
	No. 2	6·2	5·0	35·0	2·9	16·6
	Average ...	6·5	3·8	29·7	2·9	15·5

* These four samples were taken from specimens in the Natal Court of the Imperial Institute; the remainder were from the South African Products Exhibition.

† "Extractive matter" or "extract" is the percentage dissolved by treating a given quantity of the tea with one hundred times its weight of boiling water, and allowing it to infuse for ten minutes.

‡ Determined by Procter's modification of Löwenthal's process.

A consideration of the foregoing analytical figures shows that these Natal teas may be divided into two groups, which differ considerably in composition: (1) those from the Kearsney Estate, and (2) those from all other sources.

The specimens from the Kearsney Estate, grades 1 to 4, were all good black-looking teas, containing from 3·1 to 3·9 per cent. of caffeine and from 6·3 to 7·8 per cent. of tannin. The other two specimens of "Flowery Pekoe" and "Broken Pekoe" from the same source also contained a low percentage of tannin, viz., 7·0 to 7·3 per cent. These figures must be regarded as very satis-

factory, since the average percentage of caffeine (3·5) is only a little below the amount present in the Indian teas examined, and on the other hand the average amount of tannin (7 per cent.) is considerably lower. In respect of the percentage of tannin these teas from the Kearsney Estate are intermediate between the Indian and China teas. The amount of extractive matter is also less than in the Indian teas, and approximates to that of the China samples.

As is well known, it is the caffeine to which the valuable stimulating properties of tea are due, whilst the presence of much tannin is generally considered to be detrimental.

The other group of Natal teas, comprising all the remaining specimens, is characterised by unusually high percentages of caffeine and tannin. The amount of caffeine ranges from 4·0 to 4·8 per cent., with an average of 4·3 per cent.; whilst the percentages of tannin vary from 10·1 to 13·0 with an average of 11·1 per cent. The abnormal amount of tannin (13 per cent.) present in the Pekoe tea from the Clifton Estate is probably due to the fact that the sample had not been properly fermented and was more or less green. So far as the amount of extractive matter is concerned, this group agrees closely with the Kearsney teas.

The difference in the figures furnished by these two groups of specimens is very striking, and may be due to some modification in the processes of manufacture.

It was to be expected that Natal tea would show a general similarity to Indian tea, since the original seed was obtained from Assam. This similarity can be seen in the figures for the majority of the specimens and in the average results, but in the case of the Kearsney teas the small percentages of extractive matter and tannin approximate more nearly to those obtained for China teas.

These results show that the cultivation of tea in Natal and its preparation deserve very full study with a view to the production of a tea of characteristic quality. The best of these teas combine the qualities of the teas of China and India.

COFFEE.

Imports of Raw Coffee into the United Kingdom in 1907.

Consigned from—	Weight. Tons.	Value. £
British India	3,316	223,467
Aden and Dependencies	775	59,589
British West India Islands ...	743	42,845
Ceylon and Dependencies ...	174	12,155
British Central Africa Protectorate	174	10,587
British East Africa Protectorate	46	2,113
Other British Possessions ...	17	892
Brazil	24,985	815,041
Costa Rica	10,661	571,387
Other Foreign Countries	11,859	697,020
Total	52,750	2,435,103

COFFEE FROM THE CENTRAL PROVINCES OF INDIA.

A portion of the sample was submitted to a firm of brokers for commercial valuation; they described it as "fine ordinary palish-green East Indian coffee," and stated that it "would be worth from 46 to 47 shillings per cwt., London terms."

It may be explained that by "London terms" on coffee it is understood that the material when landed here is to be officially weighed, two or three pounds being allowed for tare and about one pound for draft. Further, a discount of one per cent. and a "prompt" of thirty days must be allowed to buyers.

The price quoted above is slightly higher than has recently been obtainable for coffee of this quality owing to the small general rise which has taken place in the prices of Ceylon and East Indian coffees in this market. (September, 1904.)

COFFEES FROM TRINIDAD.

Five samples of coffee were received, and after inspection were submitted in July, 1904, for valuation.

No. 1. *Coffea stenophylla* (hybrid).—This sample was stated to have been derived from hybrid plants originating in Trinidad from seeds of a true *Coffea stenophylla* which had been planted in proximity to Liberian coffee (*Coffea liberica*). The plants are of vigorous growth, fruiting freely, and are considered locally to be very suitable for cultivation at low elevations if the product is of marketable value.

The brokers described the beans as common bold coffee of slightly mixed character, and valued them at about 38*s*. per cwt. in the London market at the present time.

No. 2. *Coffea arabica* (ordinary), known locally as Creole coffee.

This was classed by the brokers as washed bold coffee, slightly mixed, and worth from 41*s*. to 42*s*. per cwt.

No. 3. This sample was stated to be the product of a variety of *Coffea liberica*, distinct from the typical form, which was obtained from Abeokuta.

It was a common pale coffee, rather mixed, and was valued at about 37*s*. per cwt.

No. 4. *Coffea stenophylla*.—This sample consisted of small beans which were valued at 35*s*. to 36*s*. per cwt.

No. 5. This sample was stated to represent the product of a variety of *Coffea arabica* which has been grown in Trinidad for many years under the name of "Moka" coffee.

The beans were very small, but were considered by the brokers to be worth from 37*s*. to 38*s*. per cwt.

For comparison with these valuations the following current London prices for Jamaica coffee may be quoted:—

	Per cwt.
Good to fine ordinary	35*s*. to 40*s*.
Fine fine ordinary	42*s*. „ 45*s*.
Greenish	48*s*. „ 65*s*.
"Colory"	75*s*. „ 122*s*.

COFFEE FROM THE EAST AFRICA PROTECTORATE.

No information was supplied regarding the origin of this sample of coffee. It was valued at about 40*s*. per cwt. in August, 1905.

COFFEES FROM ABYSSINIA.

The samples were examined and valued with the following results:—

Coffee from Anfelo.—This was a good sample of coffee of Abyssinian character; it was of pale colour, but was not well garbled. A price of from 58*s*. to 60*s*. per cwt. was quoted for it in London.

Coffee from Joté.—This was similar in character to the preceding sample, but the quality was not so good, the colour being dull and dingy. It was valued at 56*s*. per cwt.

Coffee from Goré.—This was very similar in appearance and quality to the coffee from Joté, but the berries were smaller. It would probably fetch from 55*s*. to 56*s*. per cwt. in London.

It may be noted in connection with these three samples of coffee that supplies of this type have been rather scarce of late, and in consequence high prices have been obtained. Abyssinian coffee of good quality has recently been sold in London at 60*s*. to 67*s*. per cwt. The brokers state that this class of coffee should be shipped in native-made packages and not in gunny bags.

If commercial supplies of these coffees are available there would be no difficulty in finding a market for them in Europe. (May, 1906.)

Another sample of coffee, received in 1906 from the Sudan Agent at Cairo, was purchased in Abyssinia at Dunkur, and came originally from the neighbourhood of Gambela in south-west Abyssinia. It was submitted to brokers, who reported in January, 1907, that the quality of the coffee was that of "common small Abyssinian," and stated that a large and ready sale can always be found in London for this quality of coffee, which comes on the market in quantities of 100 to 500 bags.

COFFEES FROM THE KADUR DISTRICT, MYSORE.

A sample of coffee beans was received at the Imperial Institute in 1904. It was stated that the coffee had been grown on an estate in the Kadur District, Mysore, which forty years ago produced coffee that obtained the highest prices, whereas the present prices were nearly the lowest. A second sample from the same estate, grown during the season 1905-6, was received in March, 1906. In the interval the soil of the estate had been manured with a mixture of basic slag, saltpetre, and "poonac," with the result that a remarkably good effect was noticed both in the appearance of the plants and in the yield of coffee.

It was desired, therefore, to have a comparative examination of the two samples of coffee with the object of ascertaining the effect of the manurial treatment.

The two samples were similar in appearance, but the second sample, grown after the manuring, was a little darker in colour, and the beans were rather more regular in size.

The two samples were submitted to chemical examination, and the following table shows their composition:—

	Beans grown previous to the manuring in 1904. Per cent.	Beans grown in 1905-6 subsequent to the manuring. Per cent.
Moisture	9·17	9·28
Total alkaloid, principally caffeine ...	1·22	1·46
Albuminoids	10·46 calculated from albuminoid nitrogen 1·68.	9·87 calculated from albuminoid nitrogen 1·58.
Other nitrogenous substances	1·28	0·81
Fat	11·36	11·53
Fibre	21·60	21·80
Ash	3·86	3·72
Other non-nitrogenous substances ...	41·05	41·53

The specific gravity of the beans of the first sample, viz., that grown before the manuring, was found to be 1·22, and of the second sample, viz., that grown after the manuring, 1·25.

The average weight of the beans composing the first sample was 0·156 gram, and of the second sample 0·180 gram.

The number of beans required to fill a 50 cc. cylinder was 222 in the case of the first sample and 200 in the case of the second sample, showing that the average size of the beans had increased.

The market description of the coffee was "Low, middling, greyish-green, rough, mixed, some foxy and faded." It was valued at 56*s.* per cwt. in bond, and it realised 55*s.*

The average price obtained for the previous year's crop was stated to be 52*s.*, so that a slight improvement in the value has occurred. This, however, may be partially due to market fluctuations.

It is perhaps unsafe to draw definite conclusions in this matter so soon after the manurial treatment. The examination of the next crop will furnish more trustworthy information. It is, however, clear that the manuring of the estate has had the effect of producing somewhat larger and heavier beans containing a rather higher percentage of alkaloid.

As regards further treatment of the soil, it should be noted that some laterite soils of Southern India are deficient in lime, and there is reason to believe that a more abundant supply of this ingredient would be beneficial to the soil of the coffee plantations. (October, 1906.)

Cocoa.

Imports of Raw Cocoa into the United Kingdom in 1907.

Consigned from—	Weight. Tons.	Value. £
British West India Islands, British Honduras, and British Guiana ...	6,074	491,417
Ceylon and Dependencies	3,040	254,370
British West Africa	1,411	88,755
Straits Settlements and Dependencies ...	18	1,348
Fiji	$6\frac{3}{4}$	616
Seychelles	$5\frac{3}{4}$	491
Other British Possessions	$2\frac{1}{4}$	153
Portugal and Portuguese Africa ...	7,316	603,208
Ecuador	2,536	228,028
Germany	1,669	125,591
Brazil	1,600	153,250
Other Foreign Countries	1,816	158,570
Total	25,495	2,105,797

Cocoas from Trinidad.

The two samples of cocoa were received in March, 1904; they were stated to have been grown and prepared at River Estate, Diego Martin, and to have been prepared under the supervision of Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad. No. 1 was a "select" sample which had been valued locally at $14 per 110 lb., and No. 2, described as "good ordinary," was priced at $13 per 110 lb. in Trinidad. The specimens were considered to represent the finest types of Trinidad cocoa, and had been very highly commended in the Island. It was, therefore, desired to submit them for valuation and criticism to English buyers.

The favourable opinion which had been expressed in Trinidad regarding these samples was fully confirmed by their appearance, particularly in the case of No. 1, which was a very fine specimen of cocoa. Both varieties were submitted for valuation to leading brokers, who furnished the following report:—

No. 1.—This was described by the brokers as bold, selected cocoa of good appearance, apparently well-cured and fermented.

The sample was stated to compare very favourably with the finest specimens of cocoa from the leading Trinidad estates. Its value in the London market was estimated at 75*s*. to 77*s*. per hundredweight in quantity, but for a few bags only, if every bean were as large as in the sample, possibly 100*s*. per hundredweight might have been obtained. The brokers stated that a small lot of fine Maracaibo cocoa had just been sold at 110*s*. per hundredweight.

No. 2.—The brokers described this as small, clean cocoa, worth from 60*s*. to 63*s*. per hundredweight in London.

It is evident, therefore, that the cocoa prepared at River Estate, Trinidad, was of very good quality, and that the "selected" sample compared very favourably with the highest qualities in the market.

Cocoa from Uganda.

This sample of cocoa, grown in the Botanic Garden at Entebbe, was received in December, 1906, at the Imperial Institute, from the Acting Deputy Commissioner for Uganda. It was described as having been "cured by rough-and-ready methods," and a request was made for a report on its quality and commercial value.

The sample, which weighed 4 lb., consisted of apparently unwashed and unpolished beans, varying in colour from pale dull pink to dark brownish-red. Traces of the saccharine pulp were in most cases still adhering to the beans. The latter were of medium size and rather shrivelled; they broke fairly readily, and the fractured surface was dark and slightly purple, indicating that the beans had not been fully fermented. The taste was much milder than that of West Indian cocoa, so that the incompletely-fermented condition was less important than would otherwise have been the case.

The cocoa was submitted to a firm of brokers, who stated that it was "of good appearance, reddish skin, but poor 'break,' rather dark and slaty." It was valued at 76*s.* per cwt. in London, thus showing that it would take about the same rank as good quality Ceylon and second grades of Jamaica and St. Lucian cocoas. Consignments of similar character would probably find a very good market.

This experimental cultivation of cocoa in Uganda has thus given very promising results, and the matter deserves further attention in the Protectorate.

Cocoas from the Gold Coast.

A number of samples of cocoa beans were forwarded to the Imperial Institute for examination by the Director of the Botanical and Agricultural Department of the Gold Coast Colony in August, 1905.

The collection of samples was stated to represent the products obtained in a series of experiments conducted "in the preparation of cocoa grown in the Botanical Gardens at Aburi with a view to ascertaining the most satisfactory method to adopt in preparing this product for market."

Description of Samples.

Seven samples of cocoa beans were received. These were described as follows:—

No. I	...	Fermented 8·5 days	...	Washed.
No. IV*a*	...	,, 4·5 ,,	...	,,
No. IV*b*	...	,, 4·5 ,,	...	Unwashed.
No. V*a*	...	,, 6·5 ,,	...	Washed.
No. V*b*	...	,, 6·5 ,,	...	Unwashed.
No. VI*a*	...	,, 7·5 ,,	...	Washed.
No. VI*b*	...	,, 7·5 ,,	...	Unwashed.

All seven samples consist mainly of medium-sized beans, but in several a number of small and shrivelled beans are included. The colours of the beans are on the whole poor, Nos. IV*a*, IV*b*, and I being the best in this respect. The husked cocoas, in all cases, show a faint purple tint and do not "break" readily, indicating that they are incompletely fermented. This is the case even with samples Nos. I and VI, which are described as having been fermented for 8·5 and 7·5 days respectively. As regards the colour and "break" of the husked cocoas, Nos. IV*a* and IV*b* appear to be the best of the seven samples, in spite of the fact that they were fermented for the shortest period (4·5 days). Nos. I, IV*a* and IV*b* contain a few mouldy beans, and the others a large proportion, in one case nearly 10 per cent. of partially perished beans. The flavour and aroma of all the samples are mild and rather poor when compared with those of good West Indian cocoas.

Chemical Examination.

The samples were analysed and gave the results recorded in the following table:—

No. of sample.	Method of preparation.	Husk.	Calculated on the husked samples.			
			Moisture.	Fat.	Ash.	Total alkaloid.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
I	Fermented 8·5 days and washed ...	8·0	4·55	48·29	2·39	1·28
IV*a*	Fermented 4·5 days and washed ...	8·0	4·87	46·63	3·05	1·65
IV*b*	Fermented 4·5 days unwashed ...	8·0	4·75	46·17	2·90	1·58
V*a*	Fermented 6·5 days and washed ...	8·0	4·89	44·51	2·74	1·20
V*b*	Fermented 6·5 days unwashed ...	11·4	5·00	45·30	2·66	1·40
VI*a*	Fermented 7·5 days and washed ...	8·4	4·55	44·50	2·67	1·22
VI*b*	Fermented 7·5 days unwashed ...	10·4	4·90	45·20	2·87	1·21

The results of the chemical examination show that the samples are satisfactory so far as chemical composition is concerned. It is of interest to note that the analyses indicate that samples Nos. IV*a* and IV*b* in spite of their short period of fermentation have been more thoroughly fermented than several of the others; thus the amount of husk in No. IV*b*, though unwashed, is only 8·0 per cent., identical with that found in the washed twin sample IV*a*, indicating that in these two samples practically the whole of the pulpy saccharine matter originally adherent to the shell had been utilised in maintaining the fermentation, so that none was left to be removed by the subsequent washing.

*Commercial Valuation of Samples.**

Specimens of all seven cocoas were submitted in the first instance to a firm of manufacturing confectioners, who reported on them as follows:—

"These samples are considerably better than ordinary West African cocoa; this however is not saying much, as this is the lowest grade of cocoa excepting Hayti for which there is any considerable market.

"The writer prefers the flavour of the unwashed samples in each case. He would say that sample IV*b* is very similar to a mild Grenada, whilst samples V*b* and VI*b* have more of the Trinidad quality. Some of the samples show signs of mould, which of course detracts from their value."

This firm also offered the following general remarks with regard to the condition of the West African cocoa trade.

"The bulk of the cocoa which comes over to the European market from West Africa has received hardly any fermentation at all. The pods are simply opened and the beans dried without any attempt at proper fermentation. In our opinion no amount of grading of this kind of cocoa would materially improve the price. On the other hand, if the cocoa is properly prepared, as is done in the Portuguese island of San Thomé and in the British island of Grenada, a superior quality of cocoa would be obtained, and if fermentation is done regularly the quality will be uniform."

Samples of the cocoa were also submitted to a firm of brokers in London for valuation. They reported on them as follows:—

"Sample No. I.—Bold, colory reddish, even but dark 'break'; worth about 50 to 51 shillings per cwt.

"Sample No. IV*a*.—Pale reddish, fairly good 'break'; worth about 50 shillings per cwt.

"Sample No. IV*b*.—Pale reddish, apparently washed, part lean and small; worth about 49 shillings per cwt.

"Sample No. V*a*—Dull reddish, fair 'break'; worth about 49 shillings per cwt.

"Sample No. V*b*.—Very dull, dark 'break'; worth about 47 shillings per cwt.

"Sample No. VI*a*.—Very dark, dull 'break'; worth about 48 shillings per cwt.

"Sample No. VI*b*.—Very grey and coated, but fair 'break'; worth about 48 shillings per cwt.

"During the past few months [*i.e.* late in 1905] prices of almost all descriptions of cocoa have favoured buyers, owing to large crops of Trinidad, Bahia and African sorts, and present values are moderate. Cocoa cured and prepared as samples

* Since these valuations were made prices of cocoa beans have varied considerably, so that the figures quoted are only of value for comparison with prices obtainable for standard varieties at the same time, viz., medium Ceylon at 46*s*. to 53*s*. and St. Thomé at 50*s* to 53*s*. per cwt.

represent would attract attention and compete with St. Thomé and West Indian kinds and would fetch good prices here."

As most of the West African cocoa which reaches this country is imported viâ Liverpool, it was considered advisable to have the samples valued also by a firm of brokers in Liverpool. This firm reported as follows:—

Samples Nos. V*a*, V*b* and IV*b* we consider good cocoas, the value of which to-day would be 42 to 43 shillings per cwt. *ex* quay Liverpool, usual terms.

"The other four samples contain defective beans and are therefore not quite the same value as the first three. They would probably realise 40 to 41 shillings per cwt., usual terms. The 'usual terms' means landing expenses, and less 2½ per cent. discount, merchants' and brokers' commission, &c., all to be paid by importer."

General Conclusions and Recommendations.

The foregoing results show that these samples of cocoa appear to be superior to the ordinary West African cocoa now imported into this country, and that if cocoa similar to the present set of samples could be regularly exported it would probably secure better prices than are now generally obtainable for the West African product.

These preliminary experiments in the improvement of cocoa may therefore be regarded as having given promising results, and it is desirable that they should be continued. Judging from the results of the present examination, it would seem that future progress may probably best be made by devoting attention to the mode in which the fermentation is carried out, since on this the flavour, aroma and colour of the product will principally depend.

The information contained in the foregoing report was communicated to the authorities in the Gold Coast Colony, and it was suggested that small consignments of the best quality of cocoa produced by different planters should be sent to the United Kingdom for sale, in order to obtain trustworthy information regarding the value of the better grades of Gold Coast cocoa in the open market.

This suggestion was approved by the Governor of the Gold Coast, and subsequently information was received that it had been decided to ship 20 tons of cocoa, selected by the Director of Agriculture and consisting of "one ton lots," from 20 different farmers, for sale in this country. It was arranged by the Imperial Institute that these consignments of cocoa should be sold at public auction in Liverpool.

The first consignment, consisting of 114 bags *ex* "Nigeria," was received by the brokers on the 19th January, 1907.

The brokers withdrew samples of the different lots included in this consignment and furnished the following report regarding them:—

"No. 1 (20 bags).—Bright, clean, beans of fair size but not sufficiently fermented; very saleable quality, worth 67*s.* to 68*s.* per cwt.

"No. 2 (20 bags).—Bright, clean and sound beans of fair size but only partly fermented; very saleable quality, value 68*s*. per cwt.

"No. 3 (19 bags).—Bright, sound beans, on the whole fairly well fermented but containing some percentage of unfermented beans mixed with small beans; very saleable quality, value 68*s*. to 69*s*. per cwt.

"No. 4 (15 bags).—Large beans of good quality and well fermented. The most desirable lot; very saleable, value 73*s*. to 75*s*. per cwt.

"No. 5 (13 bags).—Sound beans of fair quality but mostly unfermented and mixed with small beans; saleable, value about 66*s*. per cwt.

"No. 6 (9 bags).—Bright beans of fair quality but mixed with small and defective beans; value about 64*s*. per cwt.; saleable.

"No. 7 (7 bags).—Beans of moderate quality and fair size; distinct traces of mouldy beans; value about 63*s*. per cwt.

"No. 8 (11 bags).—Fair quality, mostly unfermented beans mixed with small and thin beans; value about 65*s*. per cwt."

The whole of this consignment was sold at an average price of 68*s*. per cwt.

All the parcels were saleable cocoas, but No. 4 was specially commended as representing the standard of quality which should be aimed at. Such cocoa would compete with the better kinds, such at St. Thomé, whereas if only slightly below this in quality, the price realised would be from 5*s*. to 7*s*. 6*d*. per cwt. lower.

The second portion of the consignment consisted of 60 bags *ex* "Akabo," which were received at Liverpool on 2nd February, 1907. The following opinions of the different lots were supplied by the brokers previous to the sale:—

"IV. (5 bags).—Good, fair beans of good size mixed with slatey beans. Value about 68*s*. per cwt.

"V. (7 bags).—Fair quality, mixed with small and defective beans. Value about 67*s*. per cwt.

"VI. (12 bags).—Fair quality but small and unfermented. Value about 67*s*. per cwt.

"VII. (13 bags).—Fair quality, mixed with small and lean beans. Value about 68*s*. per cwt.

"VIII. (9 bags).—Fair quality, mixed with small and defective beans. Value about 67*s*. per cwt.

"IX. (14 bags).—Moderate quality, very small, badly cured, and mixed with defective beans. Value about 65*s*. per cwt."

The lots were sold separately and realised the following prices in bond:—

IV.—70*s*. per cwt.	VII.—69*s*. per cwt.
V.—68*s*. ,, ,,	VIII.—65*s*. ,, ,,
VI.—67*s*. ,, ,,	IX.—65*s*. ,, ,,

The brokers stated that they were rather surprised at the high price realised by one or two of the lots, which went to a Continental buyer.

Samples of the different lots were supplied to several English manufacturers, and in certain cases criticisms and valuations were obtained, which may be quoted.

One firm stated that they could not report favourably upon the cocoa, since none of the lots would rank as average good Grenada estate cocoa. They added that lower grades of cocoa, like the present consignments, are often keenly bid for by makers of common chocolate, and realise prices which, in their opinion, are much higher than the quality justifies. They prefer not to buy such cocoas themselves, so long as good estate cocoa can be obtained at a reasonable price. In their opinion Nos. 2, 3, 4 (ex "Nigeria") and No. IV. (ex "Akabo") appeared to be the best samples, at the same time they considered that better cultivation and more experience in fermenting the beans would lead to considerable improvement in the quality of the cocoa.

A second firm of manufacturers classified the cocoas, as regards commercial value, in five divisions as follows:—

A.	Nos. 4 and IV.
B.	,, 3 ,, 7.
C.	,, 1 ,, 2.
D.	,, 5, 8, V., VI., VII., VIII., and IX.
E.	,, 6.

The Arabic numbers represent the samples ex "Nigeria," the Roman those ex "Akabo."

They stated that samples 4 and IV. alone appeared to have had any effective fermentation, and that even in these samples it is not quite regular.

Conclusions.

For comparison with the prices obtained for these Gold Coast cocoas the following particulars may be quoted regarding the current rates for cocoa in Liverpool and London at the time of the sales:—

Liverpool Market, January 23, 1907.

	Per Cwt. s. s. d.
San Thomé	73 to 74 0
African	62 ,, 70 0
January 30.	
San Thomé	69 ,, 72 6
African	60 ,, 69 0
February 6.	
San Thomé	80 ,, 84 0
African	60 ,, 69 0

London Market, January 23, 1907.

		Per Cwt.
		s. *s.* *d.*
Ceylon	Plantation: special marks ...	76 to 95 0
,, ...	,, red to good ...	76 ,, 86 0
,, ...	Native estate, ordinary to red	65 ,, 77 0
Java and Celebes...	Small to good red	60 ,, 95 0
African:—		
San Thomé ... / Cameroons ...	Grey to colory	78 ,, 85 0
Accra... ...	Fair reddish	63 ,, 75 0
Congo ...	Red to colory...	70 ,, 82 6

A comparison of the brokers' valuations of the eight lots ex "Nigeria" with the Liverpool prices of the same date shows that one sample, No. 4, was considered to be superior to the best West African cocoa then offered on the market. Three other samples, Nos. 1, 2, and 3, were valued at a little below the top market price, viz., at 66*s.* to 69*s.* per cwt., whilst the other four lots were valued at from 63*s.* to 66*s.* per cwt. at a time when 60*s.* was the lowest market quotation for West African cocoa.

Sample No. 4 of this consignment was of very good quality and was commended by the manufacturing firms consulted. There is no doubt that if cocoa of this quality can be regularly prepared in the Gold Coast it will realise very good prices in the market.

The six lots ex "Akabo" realised from 65*s.* to 70*s.* per cwt. compared with the market price of 60*s.* to 69*s.* per cwt. Only one sample, No. IV., realised 70*s.* per cwt., but three others, Nos. V., VI., and VII., fetched 68*s.*, 67*s.*, and 69*s.* per cwt., respectively; whilst the other two were sold at 65*s.* per cwt.

The principal defect of these Gold Coast cocoas as a whole is insufficient fermentation, which considerably reduces their market value in comparison with other varieties. If the preparation of the cocoa could be improved in this respect, much better prices would be realised. In addition, the presence of small and mouldy beans in many of the samples also reduces their quality and value. The occurrence of a considerable proportion of small beans is no doubt due to defective methods of cultivation, whilst the development of mould in some of the cocoas may be attributed to insufficient drying after fermentation. Considerable improvement could be effected in all these directions, with the result that the quality of the cocoa would be greatly enhanced. The native farmers should be encouraged to produce cocoa similar to sample No. 4 ex "Nigeria."

COCOA FROM BRITISH HONDURAS.

This sample of cocoa from British Honduras was received at the Imperial Institute from the Colonial Office in 1907.

The sample weighed 30 lb. and consisted of fairly large, plump, well-fermented beans, which possessed a good "break" and were

free from mouldiness. Its taste was mild and not excessively bitter.

The cocoa was similar in quality to the best grades of Trinidad cocoa which reach the English market, and a firm of brokers to whom it was submitted stated that it would meet with a ready sale in this country. It was valued in London at from 110*s.* to 111*s.* per cwt. in bags, subject to the usual conditions, at a time when the finer grades of Trinidad cocoa were quoted at 110*s.* to 112*s.* per cwt.

KOLA NUTS.

A considerable trade in kola nuts is carried on in the West African Colonies, the Gold Coast and Sierra Leone being large exporters, while Southern Nigeria and Gambia are large importers.

Exports of Kola Nuts from the Gold Coast in 1907.

To	Quantity. Packages.	Value. £
The United Kingdom	75	117
Germany	2,159	1,870
Southern Nigeria	4,037	76,803
Other places	7	111
Total	6,278	78,901

Exports of Kola Nuts from Sierra Leone in 1907.

To	Fresh nuts. Weight. Tons.	Fresh nuts. Value. £	Dried nuts. Weight. Tons.	Dried nuts. Value. £
United Kingdom	5¼	513	2¾	55
Other places	1,365	113,085	1	21
Total	1,370¼	113,598	3¾	76

In the case of fresh nuts the places other than the United Kingdom are all on the West Coast of Africa.

KOLA NUTS FROM THE GOLD COAST.

These samples of kola seeds, commonly known as "kola nuts," were included in a collection of products forwarded for examination to the Imperial Institute by the Director of Agriculture in the Gold Coast, and were received in January, 1906.

Two varieties of seeds, white and red, were submitted for analysis, and both fresh and dried specimens of each were supplied. It was stated that the Hausas, who are the largest purchasers of these seeds, prefer the white to the red variety, and also believe that they lose a large proportion of their tonic properties

when dried. It was therefore desired to have comparative analyses made of the white and red seeds in the fresh and dried condition, in order to determine whether there is any support for the native opinion.

The samples were collected in East Akim, and were as follows:—

Fresh White Kola Seeds.—This sample, weighing 210 grams, consisted of eleven seeds of the size of large chestnuts. They were packed in damp charcoal, and appeared to be quite fresh on arrival. The seeds had a pale straw colour, but the freshly-cut surface rapidly turned brown.

Fresh Red Kola Seeds.—Twelve seeds, the total weight of which was 290 grams, were supplied. The seeds were the size of chestnuts, and were carmine externally and pink internally. On cutting the seed, the exposed surface soon turned brown.

Kola Seeds, Dry, White.—They were very hard and of a dark reddish-brown colour. Fourteen seeds weighed 72 grams.

Kola Seeds, Dry, Red.—They were very hard, and of a reddish-brown colour. Nine whole seeds and ten pieces weighed in all 87 grams.

The percentage of moisture and of total alkaloids in the kola seeds were determined, with the following results:—

—	Moisture.	Total alkaloids, principally caffeine.	
		Calculated on original substance.	Calculated on water-free substance.
	Per cent.	Per cent.	Per cent.
Fresh seeds, white	67·7	0·76	2·36
" " red	55·9	0·88	2·00
Dry seeds, white	11·8	2·19	2·48
" " red	15·6	1·97	2·33

Samples of the dry seeds were submitted to commercial experts, who reported that they were rather small and in a musty condition. Most of the seeds were whole, whereas buyers in this country prefer them split. It was thought that kola seeds of the quality of the samples might realise $1\frac{1}{2}d.$ per lb. in London, but the current value of good qualities is $2\frac{1}{4}d.$ to $2\frac{1}{2}d.$ per lb. The experts stated that the colour does not appear to make any difference, as white and red seeds sell equally well here, and if there is any preference at all it is in favour of the red variety.

The results of the chemical examination show that there is little difference in the amount of caffeine present in the white and red seeds, although in these four samples the white seeds have a slight advantage in this respect. It would, however, be unsafe to conclude, without further analyses, that the white seeds contain as a rule more caffeine than the red.

The results of the present investigation do not support the view that the seeds deteriorate on drying, as the proportion of caffeine calculated on the dry material is a little higher in the dry than in the fresh seeds, though no doubt the latter are more agreeable for chewing as a condiment.

Bitter Kola Nuts from the Gold Coast.

The samples were received in December, 1906, and were described as follows:—

"AI. Eleven bitter cola nuts; native name Bisetro (False Cola)."

"AII. One hundred nuts of Bisetro (False Cola), dried; when fresh the nuts weighed 11 lb., and dried to 5 lb. 10 oz."

"BI. Eighteen bitter cola nuts; foliage very large; appears to be a different tree from the above."

The nuts, which consisted of four cotyledons, were dark brown, and varied between one and two inches in length. Some of them were wedge-shaped, while others were irregularly four-sided. In Sample AII, which had been dried, the nuts had separated into the cotyledons.

There was no very marked difference between the three samples, except that AI and BI were whole nuts, whereas AII consisted of split nuts. In all three cases the nuts were somewhat larger than those of commerce.

The percentages of moisture and of total alkaloid in the nuts were determined with the following results:—

—	Moisture.	Total alkaloids, principally caffeine.	
		Calculated on material as received.	Calculated on dry material.
	Per cent.	Per cent.	Per cent.
AI	11·8	1·165	1·32
AII	10·1	1·186	1·31
BI	12·4	1·485	1·69

The alkaloid obtained in the determinations was crystalline, and consisted almost entirely of caffeine.

The amount of total alkaloid present in these specimens agrees with that usually recorded for ordinary kola nuts which contain from 1 to 2 per cent.

Wild Kola, *Sterculia* Species, from Northern Nigeria.

This specimen of "wild kola," *Sterculia* sp., known by the natives as Migin Goro, was included in a collection of native

products which was forwarded by the Forestry Officer in Northern Nigeria.

The specimen was labelled "Wild Kola, *Sterculia* sp.," and consisted of 25 grams of the seeds of the plant.

Chemical examination showed that no caffeine or other similar alkaloid is present in the seeds, which cannot therefore possess any of the properties of ordinary kola. The material does not appear to be of any commercial value. (April, 1907.)

"RANAWARA TEA" AND LEAVES AND FLOWERS OF *Cassia auriculata* FROM CEYLON.

A sample of the leaves of *Cassia auriculata*, known as "Ranawara tea," prepared and packed in a form ready for sale, was forwarded for examination to the Imperial Institute from Ceylon in 1904, and was the subject of a preliminary report. It was found that the leaves contained a small amount of alkaloid, probably caffeine, but the quantity of leaves available was too small to permit the alkaloidal constituent to be definitely identified.

A larger quantity of the "tea," together with samples of the unprepared leaves and flowers of the plant, was accordingly forwarded for further investigation to the Imperial Institute by the Superintendent of the Government School Gardens, Colombo, and was received in August, 1905.

The samples consisted of (1) seven pounds of "No. 1 Ranawara tea," which resembled the sample previously examined; (2) seven pounds of the dried leaves—these were brownish-grey, thin and brittle, about one inch long and a quarter of an inch wide; (3) three and a-half pounds of expanded flowers, consisting largely of dried yellow petals; and (4) three pounds of unexpanded grey flower buds.

All the samples were carefully examined for the presence of caffeine, but this alkaloid, or one resembling it, could only be detected with certainty in the sample of "No. 1 Ranawara tea."

In order to explain the presence of caffeine in the prepared "tea," and its absence in the leaves and flowers, attempts were made to ascertain if ordinary tea, either as leaf or dust, had been added. Careful microscopical examination, however, failed to reveal the presence of tea leaves or dust.

The presence of a minute quantity of caffeine in the "Ranawara tea," and the failure to discover this alkaloid in the unprepared leaves and flowers of *Cassia auriculata*, suggest the possibility of the presence of caffeine being due to some substance having been added to the *Cassia auriculata* leaves in the course of the preparation of the "tea."

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Botanical names are printed in italics.

COLONIAL REPORTS—MISCELLANEOUS.

No. 82.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT.

Edited by the DIRECTOR.

IV.—RUBBER AND GUTTA PERCHA.

(For Part I., Fibres, *see* No. 58 [Cd. 4588] of 1909; for Part II., Gums and Resins, *see* No. 63 [Cd. 4971] of 1909; and for Part III., Foodstuffs, *see* No. 71 [Cd. 5137] of 1910.)

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No. 82.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

IV.—RUBBER AND GUTTA PERCHA.

INTRODUCTION.

The selection of reports on rubber now brought together relate chiefly to the composition and quality of the rubber furnished by well-known rubber-producing trees, such as *Hevea brasiliensis*, grown in different countries and under different climatic conditions and prepared in different ways, as well as to rubber furnished by a number of other trees and plants which are less well known, many of which however may prove to be of value in those countries in which the cultivation of Hevea and other important rubber producers is not possible. These reports have nearly all been made at the request of the Governments of the British Colonies concerned, and are based upon investigations and analyses conducted in the Scientific and Technical Department of the Imperial Institute, which have engaged the attention of several members of the staff, especially Mr. Harold Brown and Dr. S. S. Pickles. In many cases these investigations have been followed by technical trials by manufacturers and valuations by well-known brokers, of whose assistance I take this opportunity of expressing my cordial acknowledgments.

In addition to the results recorded in these reports a very considerable body of work has been carried out in the Scientific and Technical Department of the Imperial Institute relating to those unsolved problems of the rubber industry, such as the best methods of coagulating latex and of curing rubber, the causes of "tackiness" of rubber and of the peculiarities in composition of one and the same rubber when cultivated under different conditions. It has not been thought desirable to include the results of these preliminary investigations with the present reports, because in most cases definite conclusions have not been reached, and in any case these results await further evidence derived from experiments now in progress in the various Agricultural Departments in the Colonies before trustworthy conclusions can be drawn.

For similar reasons the results of investigations into improved methods of analysis and into the correlation of the results of chemical analyses and physical tests which have not yet reached finality are not included. The problem of the exact connection between chemical composition and physical properties is one of the most important for the future of the rubber industry, and will only be solved by investigations conducted on strictly scientific lines. Owing chiefly to the complex chemical nature of rubber and to the fact that special methods of research are required, some time must elapse before our knowledge of the connection between composition and elasticity, strength, and other physical properties, on which the commercial value of rubber depends, can be placed on a satisfactory footing.

The rubber planting industry is now in a transition stage, and is faced with several problems which will only be satisfactorily solved by systematic research, much of which must necessarily be conducted on the spot. It is a welcome and hopeful feature that this need for investigation is generally recognised, and not only are these problems being attacked by the Government Agricultural Departments in the tropics, many of which are conducting investigations in conjunction with the Imperial Institute, but many of the larger plantation companies have engaged the services of scientific specialists to conduct investigations into the important problems of tapping, coagulation, curing, and the large subject of the hygiene and pathology of rubber plantations, upon the successful solution of which the future of this great industry depends.

So long as rubber commanded a very high price considerable importance attached to those plants which furnished even a relatively small amount of this material, since the profitable separation of the rubber from resins and other foreign substances naturally associated with it in the latex was commercially possible. With a very considerable fall in the price of rubber and with a greatly enhanced production of first-class rubber these secondary and inferior sources of the material are less likely to be of importance. A number of such products are alluded to in these reports, some of which also relate to gutta percha, which is closely allied in some respects to rubber, and was once very extensively employed and purchased at a high price for certain electrical purposes. Now, however, the commercial position of gutta percha is greatly changed, owing to the fact that rubber itself in combination with other substances can be employed for many of those purposes for which gutta percha was not long ago alone suitable.

Lastly reference may be made to the investigations conducted at the Imperial Institute into the value of the seeds of the Para rubber tree as a source of oil, as to which reports are included in the present series. It is now some years ago since the oil contained in these seeds was first investigated as to its composition and uses at the Imperial Institute. It was shown that the kernel of this seed, which is easily removed from the thin shell, contains nearly half its weight of oil. This oil was found closely to resemble linseed oil in its composition and properties, falling into

the class of drying oils, which are used in the manufacture of paints, of linoleum, and of other materials. It was shown that this oil would command about the same value as linseed oil, and that there would be a considerable demand for it as a substitute for linseed oil. At first the matter did not seem to be of much immediate importance. Rubber was commanding a high price, and the planter was not inclined to devote attention to a bye-product. Moreover large quantities of seed were not then available, and all seeds were readily taken up at high prices for planting purposes. With the maturing of large rubber plantations all over the world the need for seed for planting is rapidly diminishing, and an enormous quantity of seeds is becoming available. At the same time the fall in the price of rubber and the circumstance that the cost of labour in the plantations will certainly increase has caused the planter to consider the question of finding a market for the seeds. The present time is favourable for the production of rubber seed oil, since it now will command a higher price than that originally quoted, owing to the scarcity and consequent greater value of linseed oil. The reports on this subject which are included in the "Appendix" summarise the present position of the question. The residue or cake left after expression of the oil would be of value as a manure and also possibly as a feeding stuff for animals, and trials on this subject have now been instituted by the Imperial Institute, whilst the question of the cost of collecting the seeds, and the possibility of expressing the oil on the spot, are engaging the attention of rubber planters in several Colonies.

It may be useful to add that specimens of all the materials described in these reports are to be seen in the Public Galleries and Reference Collections of the Imperial Institute.

It may also be added that reports on rubber investigations and information respecting the problems of the rubber industry are published in the quarterly "Bulletin of the Imperial Institute."

WYNDHAM R. DUNSTAN.

September, 1911.

PARA RUBBER.

Hevea brasiliensis, Muell. Arg.

The Para rubber tree belongs to the natural order Euphorbiaceæ, and is a native of the Amazon Valley, where it occurs principally to the south of the main stream in the countries of Brazil, Peru, and Bolivia. It is widely distributed throughout this region, being found in the low-lying forests of the lower Amazon, which are subject to annual inundations, and also, further up the river, on the higher ground which is never flooded. The characteristic features of the climate of the low forests are a considerable rainfall well distributed throughout the year, and a very uniform temperature.

Hevea brasiliensis is a large forest tree which attains a height of 60 feet and a circumference of 10 to 12 feet. It is the chief source of the world's supply of rubber, and the product which it furnishes is also of the highest quality, forming the market standard of value. The amount of Para rubber produced in South America during the season 1909-10 was over 39,000 tons, or nearly one half of the world's estimated total supply of 80,000 tons in the year 1910.

The Para tree has proved to be very suitable for general cultivation throughout the tropics, and it has been successfully introduced on a large scale into Ceylon, the Malay Peninsula, Sumatra, Java, and Borneo, where its cultivation now forms one of the most important planting industries; it is also being grown to a smaller extent in Southern India and Burma. The Para tree has been planted experimentally in most of the British Colonies and Protectorates in Africa, in Seychelles, in British Guiana, and in some of the West Indian Islands, and in many of these countries it has given very promising results.

It is estimated that at the end of 1910 there were 600,000 acres planted with Para rubber trees in Ceylon and Malaya and 140,000 acres in the Dutch East Indies. The yield of rubber from cultivated Para trees in the East was about 8,000 tons in 1910. The plantation Para rubber is of very high quality, and up to the present it has usually realised prices slightly in excess of that of fine hard Para from South America.

In Brazil the Para trees are tapped by making a number of small incisions in the trunk, and the latex is afterwards coagulated by exposing it in thin layers to the dense smoke given off by the burning shells of certain palm nuts. The rubber is thus obtained in the form of large balls, composed of concentric layers, and it has a strong odour of creosote derived from the smoke.

Many methods of tapping have been tried on the Para plantations in Ceylon and Malaya, but the one most generally adopted at present is the herring-bone or half herring-bone system, which consists of a vertical channel with lateral cuts communicating with it on one or both sides. The lower edge of the cut is usually re-opened every other day by pricking or by paring off a thin slice of bark, when a fresh flow of latex occurs. The yield of latex increases with successive tappings until a maximum is reached and then it gradually diminishes. The latex is usually

coagulated by the addition of a little acetic acid and the rubber is prepared in biscuits, *i.e.*, thin circular cakes, or by means of machinery in sheet, crêpe or block.

The average yield of smoked rubber from forest trees in the Amazon area has been given as 2½ kilos (5·5 lb.) per tree per annum, whilst the average yield of dry rubber from the whole of the trees tapped in the Malay Peninsula during 1908 was 1 lb. 15¾ oz. per tree. In Negri Sembilan, however, the average yield of dry rubber from over 300,000 trees was 3lb. 2¼ oz. in 1908.

The results of the examination at the Imperial Institute of Para rubber from India, the Federated Malay States, Seychelles, Zanzibar, Southern Nigeria, Trinidad, and Dominica are given in the following section.

INDIA.

I.—*Para Rubber from Mergui, Burma* (1907).

This sample of Para rubber, prepared from trees in the Government plantation at Mergui, weighed about 2 oz., and consisted of two thin sheets of pale rubber, which was clean and well prepared. The physical properties of the rubber were very satisfactory.

A chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·5	—
Caoutchouc	95·2	95·7
Resin	1·6	1·6
Proteid	2·4	2·4
Ash	0·3	0·3

The rubber was valued at 5*s*. 6*d*. per lb. in London, with fine hard Para from South America quoted at 5*s*. 2*d*. per lb., and Para biscuits from Ceylon and the Federated Malay States at 5*s*. 6*d*. per lb.

The rubber was of excellent quality, and compared favourably in composition and physical properties with samples of Para rubber from Ceylon and the Federated Malay States. Consignments of similar character would find a ready sale at good prices.

II.—*Para Rubber from Kullar, Nilgiris* (1908).

The sample was labelled as follows:—"No. 4. Para rubber from trees planted in the Government Experimental Garden, Kullar (1,300 feet), Nilgiris, in April, 1902; collected June, 1908." It weighed 7¾ oz. and consisted of two large biscuits of dark brown rubber, containing traces of vegetable impurity. The rubber was of good quality but rather deficient in strength.

The results of the chemical examination are given in the following table:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·8	—
Caoutchouc	92·0	92·8
Resin	2·6	2·6
Proteid	3·0	3·0
Ash	1·6	1·6

The rubber was valued at 5*s*. to 5*s*. 2*d*. per lb. in London, with fine hard Para quoted at 5*s*. 1*d*. per lb. and plantation Para biscuits from Ceylon and the Federated Malay States at 5*s*. 3*d*. to 5*s*. 9*d*. per lb.

This rubber was very satisfactory in composition but the biscuits were dark coloured and contained specks of vegetable impurity.

III.—*Para Rubber from Burliar, Nilgiris* (1908).

The specimen bore the following label:—"No. 5. Para rubber from the Government Experimental Gardens, Burliar (2,400 feet), Nilgiris. Trees planted November, 1898; rubber collected November, 1907." It weighed 17¼ oz. and consisted of two biscuits and three long narrow strips of rubber, rather uneven in colour, and containing traces of vegetable impurity. The rubber was in good condition and possessed fair strength. It had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·4	-
Caoutchouc	91·5	91·9
Resin	3·9	3·9
Proteid	3·7	3·7
Ash	0·5	0·5

The rubber was valued at 5*s*. 4*d*. to 5*s*. 5*d*. per lb., with fine hard Para quoted at 5*s*. 1*d*. per lb. and plantation Para biscuits from Ceylon and the Federated Malay States at 5*s*. 3*d*. to 5*s*. 9*d*. per lb.

This sample of Para rubber was much lighter in colour than the preceding specimen, but like the latter it contained minute vegetable fragments which should be removed from the latex by straining.

FEDERATED MALAY STATES (1906).

These samples of Para rubber, which had been specially prepared in the Federated Malay States, were forwarded to the Imperial Institute by the Director of Agriculture at Kuala Lumpur, with a request that they should be submitted to chemical examination in order to determine their purity.

The samples, sixteen in number, furnished the following results on chemical examination:—

Sample.	Description.	Weight.	Moisture.	Caoutchouc.	Resin.	Proteid.	Ash.
		grams.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	Crêpe, pale yellow	245	0·22	94·60	2·75	2·27	0·16
2	Large thin biscuits, pale ...	225	0·36	94·81	2·23	2·31	0·29
3	Thin sheets, pale, opaque ...	255	0·54	94·68	1·64	2·66	0·48
4	Crêpe, almost white	180	0·26	92·64	3·58	3·18	0·34
5	Crêpe, dark brown	235	0·60	93·45	2·89	2·50	0·56
6	Sheet, very pale	230	0·38	94·40	1·78	3·08	0·36
7	Crêpe, almost white	260	0·32	93·68	2·83	2·99	0·18
8	Large biscuit, pale	250	0·42	95·61	1·38	2·13	0·46
9	Crêpe, light brown	240	0·28	94·48	2·82	2·19	0·23
10	Corrugated sheet, rather dark	280	0·44	94·82	2·45	1·94	0·35
11	Corrugated sheet, pale ...	280	0·38	95·15	1·83	2·36	0·28
12	Corrugated sheet, rather dark	280	0·36	94·87	2·07	2·36	0·34
13	Corrugated sheet, pale ...	320	0·52	93·42	2·57	3·06	0·43
14	Crêpe, yellow	300	0·42	93·53	3·01	2·90	0·14
15	Thin sheet, pale	280	0·22	96·35	1·87	1·35	0·21
16	Sheet, pale	340	0·38	95·47	1·75	2·13	0·27
Minimum values		—	0·22	92·64	1·38	1·35	0·14
Maximum values		—	0·60	96·35	3·58	3·18	0·56

A survey of these figures shows that the samples taken as a whole are of excellent quality, the amount of caoutchouc ranging from 92·64 to 96·35 per cent., the resin from 1·38 to 3·58, the proteid from 1·35 to 3·18, the ash from 0·14 to 0·56, and the moisture from 0·22 to 0·60 per cent. Four of the samples contain over 95 per cent. of caoutchouc, and in seven others the amount of this constituent lies between 94 and 95 per cent.

In the following table the eleven samples containing over 94 per cent. of caoutchouc are arranged according to the amount of this constituent present:—

—	Moisture.	Caoutchouc.	Resin.	Proteid.	Ash.
1. (No. 15) ...	0·22	96·35	1·87	1·35	0·21
2. (No. 8) ...	0·42	95·61	1·38	2·13	0·46
3. (No. 16) ...	0·38	95·47	1·75	2·13	0·27
4. (No. 11) ...	0·38	95·15	1·83	2·36	0·28
5. (No. 12) ...	0·36	94·87	2·07	2·36	0·34
6. (No. 10) ...	0·44	94·82	2·45	1·94	0·35
7. (No. 2) ...	0·36	94·81	2·23	2·31	0·29
8. (No. 3) ...	0·54	94·68	1·64	2·66	0·48
9. (No. 1) ...	0·22	94·60	2·75	2·27	0·16
10. (No. 9) ...	0·28	94·48	2·82	2·19	0·23
11. (No. 6) ...	0·38	94·40	1·78	3·08	0·36

It will be seen from this table that sample No. 15, which contains the highest percentage of caoutchouc, has the lowest per-

centages of proteid and moisture in the series, whilst the amount of ash is also low and not much above the minimum value; the percentage of resin is, however, a little higher than in the other three samples containing over 95 per cent. of caoutchouc.

The results of these analyses are of interest as indicating the high degree of purity which has been attained in the preparation of Para rubber from cultivated trees in the Federated Malay States.

SEYCHELLES.

I.—*Three specimens of Para Rubber from Seychelles* (1908).

No. 1. "Para rubber from Praslin."

This sample weighed 4 oz. and consisted of a small biscuit of rubber, brown externally, but white and very moist within; it had a strong sour odour when freshly cut. The rubber was weak and tore readily when stretched.

No. 2. "Para rubber from Victoria."

One biscuit of rubber weighing 7 oz. It closely resembled the preceding specimen No. 1 in appearance and physical properties.

No. 3. "Para rubber from Cascade."

One biscuit of rubber weighing 11 oz. It was very similar in all respects to the other two specimens.

The results of the chemical examination are given in the following table:—

—	Rubber as received.			Composition of dry rubber.		
	Praslin.	Victoria	Cascade.	Praslin.	Victoria.	Cascade.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	17·2	12·7	12·6	—	—	—
Caoutchouc	77·7	82·1	81·7	93·9	94·1	93·6
Resin	2·3	2·0	2·7	2·8	2·3	3·1
Proteid	1·8	2·0	2·8	2·1	2·3	3·1
Insoluble matter ...	1·0	1·2	0·2	1·2	1·3	0·2
Ash	0·1	0·3	0·1	0·1	0·3	0·1

These samples of Para rubber were stated to have been obtained from a small number of trees less than five years old, which had reached a tappable size. The results of the investigation showed that so far as chemical composition is concerned the rubber was very satisfactory, as the analytical figures compare favourably with those obtained for Para rubber from Ceylon and the Federated Malay States. In physical properties, however, the rubber was very defective, being exceedingly weak. This defect was no doubt due in part to the fact that the rubber had been prepared from young trees, but it seemed probable that the very moist condition of the biscuits had also contributed to the result.

II.—*Two specimens of Para Rubber from Seychelles* (1909).

These specimens were stated to have been prepared from young Para trees 4 to 6 years old growing at the Botanic Station and at Government House in Seychelles.

No. 1. Large cakes of rubber from ⅜ to 1 inch in thickness, light brown externally, but almost white internally. The rubber was rather moist and its elasticity and tenacity were poor.

No. 2. Large biscuit of rubber, ⅜ to ½ inch thick, almost black externally but light within. The rubber was much drier than the preceding specimen but rather weak.

The chemical examination gave the following results:—

—	Rubber as received.		Composition of dry rubber.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	12·4	3·1	—	—
Caoutchouc	81·5	90·9	93·1	93·8
Resin	3·3	2·5	3·7	2·6
Proteid	2·6	3·4	3·0	3·5
Ash	0·2	0·1	0·2	0·1

The samples were valued at about 6*s*. per lb. in London with fine hard Para quoted at 8*s*. 6*d*. per lb.

In composition the rubber is quite satisfactory, and the results of the analyses agree closely with the figures obtained for the three preceding specimens from Seychelles. The rubber is, however, very deficient in physical properties, probably owing to the fact that it was prepared from young trees. This defect will no doubt tend to disappear as the trees become older.

In appearance the rubber is fairly satisfactory, but the biscuits were made much too thick, and consequently they have not dried completely.

The results of the examination of these specimens are distinctly promising and indicate the probability that Para rubber of good quality can be successfully produced in Seychelles.

III.—*Para Rubber from Seychelles* (1910).

It was stated that this sample of Para rubber had been prepared from young trees 5 to 7 years old, and that the biscuits of lighter colour were dipped into hot water before drying.

The sample consisted of 24 biscuits of rubber from 6 to 7 inches in diameter and about ⅛ inch thick. The biscuits varied in colour from light to dark brown, but it was not possible to divide them into two distinct groups according to colour. Specimens of the lightest and darkest biscuits were therefore taken for analysis. Some of the biscuits were slightly mouldy on the surface when received, probably through having been packed before they were quite dry.

The rubber was clean and well prepared, and the strength was fairly good. In the latter respect this sample of rubber was much superior to the specimens from Seychelles dealt with in the preceding reports.

The analysis of the "light" and "dark" biscuits gave the following results:—

—	Light biscuits.		Dark biscuits.	
	Rubber as received.	Composition of dry rubber.	Rubber as received.	Composition of dry rubber.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	0·7	—	0·7	—
Caoutchouc ...	93·3	94·0	93·9	94·6
Resin	2·7	2·7	2·8	2·8
Proteid	3·0	3·0	2·3	2·3
Ash	0·3	0·3	0·3	0·3

These results show that the rubber is very satisfactory in chemical composition, the figures given above agreeing closely with those found for previous samples of Para rubber from Seychelles, and comparing favourably with those recorded for plantation Para from Ceylon and Malaya.

The rubber was submitted to brokers, who valued the light biscuits at about 7*s*. per lb. and the dark biscuits at 6*s*. 11*d*. per lb. in London, with fine hard Para quoted at 6*s*. 11*d*. per lb., and fine plantation Para at 6*s*. 11*d*. to 7*s*. 10*d*. per lb.

This rubber is very satisfactory so far as chemical composition is concerned, and its physical properties show a considerable improvement on those of the previous specimens from Seychelles. The results of the investigation confirm the view that the Para trees in Seychelles when mature will yield rubber of excellent quality.

ZANZIBAR (1908).

A small specimen of Para rubber, weighing only about 1½ oz., was received from Zanzibar for examination. It consisted of two circular discs of light-coloured rubber which had apparently been cut from a round ball. The rubber contained a fair quantity of vegetable impurity, but was otherwise of good quality; its physical properties were quite satisfactory.

An analysis gave the following results:—

	Rubber as received.	Composition of dry rubber.
	Per cent.	Per cent.
Moisture	1·7	—
Caoutchouc	83·9	85·3
Resin	4·8	4·9
Proteid	3·1	3·2
Insoluble matter ...	6·5	6·6
Ash	0·79	0·80

The rubber contained a rather higher percentage of resin than is usually present in Para rubber and the amount of vegetable impurity was excessive. The latter defect could be easily remedied by careful collection and preparation.

The specimen was too small for trustworthy valuation, but there is no doubt that the rubber, if carefully prepared, would realise a satisfactory price.

SOUTHERN NIGERIA (1909-10).

The Para tree (*Hevea brasiliensis*) has been successfully introduced into Southern Nigeria and has been found to grow well in many parts of the wet zone of the Colony (south of 6° 15′ north latitude). Experimental plantations of the trees have been established by the Forestry Department and by private firms, and these are being gradually extended.

During the latter part of 1909 two series of tapping experiments were conducted by Mr. T. Christ, of the Forestry Department, on Para trees growing at Ebute-Metta and Orugbo, and the rubber obtained was forwarded to the Imperial Institute for chemical examination and subsequent sale. A summary of the results of the investigation will therefore be of interest as indicating the yield and quality of the rubber furnished by Para trees in Southern Nigeria.

Tapping Experiments at Ebute-Metta.

The first Para trees introduced into Lagos were planted in the Botanic Gardens at Ebute-Metta. The oldest existing trees are of uncertain age, but are now (1910) probably 16 years old, as the first consignment of *Hevea brasiliensis* seedlings was sent to Lagos in 1894. Some confusion has arisen regarding the botanical identity of these old trees in the Gardens, owing to the fact that although they all appeared to belong to the same species, some of them had been labelled *Hevea brasiliensis* and others *Hevea Spruceana*. In July, 1910, however, flowering specimens of the two groups of trees were forwarded to Kew for determination, with the result that the identity of those labelled *H. brasiliensis* was confirmed, whilst those labelled *H. Spruceana* were found not to belong to that species, but to represent another form of *H. brasiliensis*. It is therefore definitely established that all the old Para trees at Ebute-Metta belong to *H. brasiliensis*.

In view of these determinations it seems very probable that the statement recently made by M. Yves Henry (see *Bulletin of the Imperial Institute*, 1910, **8.** 183) that *Hevea Spruceana* has given much more promising results that *Hevea brasiliensis* in West Africa cannot be maintained. The trees of supposed *H. Spruceana* at Porto Novo, the returns from which form the main support of his opinion, were derived from Ebute-Metta, and are no doubt similar to those which are now proved to be a form of *H. brasiliensis*.

Five of the trees labelled *H. brasiliensis* had been experimentally tapped in 1908, and four of these were chosen for further trials in 1909, together with two trees which were then thought to be *H. Spruceana*, but are now known to be a form

of *H. brasiliensis*. The experiments extended from September 22 to November 18, 1909, the trees being tapped on alternate days, and the returns from the two groups of trees were kept separate. The results are summarised in the following table:—

—	No. of tappings.	Daily yield of dry rubber.		Total yield of dry rubber.	Average total yield per tree.	Average yield per tree for each tapping.
		Minimum	Maximum.			
		oz.	oz.	lb. oz.	oz.	oz.
(a) Four trees—average girth 37 inches.	26	1¼*	4†	4 15	20	0·8
(b) Two trees—average girth 40 inches.	25	Nil*	2½‡	1 10¾	13	0·5

* First tapping. † 20th and 22nd tappings. ‡ 19th tapping.

It will be seen from these figures that the yield of rubber from the second group of trees was much less than that from the first, and it is suggested that this may possibly be due to the fact that the two trees forming the second group were tapped for the first time, whereas the other four had been tapped the previous year.

These yields of rubber, especially that given by the first group of four trees, are exceedingly promising, but further experiments are required in order to determine whether they will be maintained on tapping during a longer period than two months. It was proposed to tap the trees regularly during the greater part of 1910, except in the very dry months, and the results will be of much interest.

Three specimens of the biscuit rubber obtained in these tapping experiments at Ebute-Metta during 1908 and 1909 have been examined at the Imperial Institute. All the specimens were very similar in appearance, consisting of biscuits of light brown rubber, which was clean and well prepared. The physical properties of the rubber were very satisfactory.

The results of the chemical examination of the three specimens are given in the following table:—

—	Rubber obtained in 1908.	Rubber obtained in 1909.	
		From 4 trees tapped previously in 1908.	From 2 trees tapped for first time.
	Per cent.	Per cent.	Per cent
Moisture	0·6	0·6	0·5
Caoutchouc	95·0	95·2	92·4
Resin	1·7	1·7	4·9
Proteid	2·3	2·1	1·9
Ash	0·4	0·4	0·3

The figures show that the specimens derived from the same trees in 1908 and 1909 respectively are practically identical in composition, and that they are quite equal in this respect to plantation Para rubber from Ceylon or Malaya.

The rubber obtained from the two trees tapped for the first time in 1909 contains a much higher percentage of resin than that from the other group of trees. As already indicated, these two trees were believed at the time to be *Hevea Spruceana*, but have now been determined as a form of *Hevea brasiliensis*, and it will be of interest to see whether this high percentage of resin in the rubber will be maintained in the product obtained in subsequent tappings.

The rubber from the 1908 tapping was valued at 5*s*. per lb. in London with fine hard Para quoted at 5*s*. per lb. and fine plantation Para at 5*s*. 1*d*. to 5*s*. 8*d*. per lb.; the specimens obtained in 1909 were valued at about 9*s*. per lb. in London with fine hard Para at 9*s* 10*d*. per lb. and fine plantation Para at 10*s*. 1*d*. to 10*s*. 6*d*. per lb.

Tapping Experiments at Orugbo.

A series of tapping experiments was also conducted on Para trees (*Hevea brasiliensis*) at the Rev. J. E. Wright's plantation at Orugbo. One hundred 8-year-old trees were selected for trial, and were divided into two groups: (1) 50 trees with an average girth of 25 inches, and (2) 50 trees with an average girth of 22 inches; in addition, three trees which had been tapped in August, 1909, were re-tapped. The experiments extended from September 19 to October 30, 1909, and the tappings were made on alternate days, with the exception that the 50 trees of the first group were tapped every day for one week. The half herring-bone system was employed, the vertical channel being made 6 feet high and the lateral cuts 6 inches long. The results obtained are summarised in the following table:—

—	No. of tappings.	Daily yield of dry rubber.		Total yield of dry rubber.	Average total yield per tree.	Average yield per tree for each tapping.
		Minimum.	Maximum.			
(1) 50 trees—average girth 25 inches ...	23	2 oz.*	1 lb. 5¼ oz.†	20¼ lb.	6·5 oz.	0·3 oz.
(2) 50 trees—average girth 22 inches ...	2[illegible]	2½ oz.*	14½ oz.‡	14 lb. 2¾ oz.	4·5 oz.	0·2 oz.
(3) 3 trees previously tapped‖ ...	20	nil.°	2 oz.§	1 lb. 2 oz.	6 oz.	0·3 oz.

* First tapping. † 21st tapping. ‡ 15th and 17th tappings. § 15th tapping.
‖ These three trees gave 9 oz. of dry rubber in 8 tappings in August, 1909.

A comparison of this table with the preceding one giving the results at Ebute-Metta shows that the average yield of dry rubber per tree obtained at Orugbo in these experiments was much less than at Ebute-Metta. Further data will, however, be necessary

before any definite comparison can be made, as the trees at Ebute-Metta are almost twice the age of those which were tapped at Orugbo.

The rubber obtained in the experiments at Orugbo was forwarded to the Imperial Institute for examination and subsequent sale. The consignment weighed about 30 lb., and consisted of light-brown biscuits, which were well prepared but of rather rough appearance. The rubber exhibited very good physical properties.

On analysis the following results were obtained:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·5	—
Caoutchouc	90·8	94·1
Resin	3·6	3·7
Proteid	1·9	2·0
Ash	0·2	0·2

The results of the chemical examination show that the dry rubber is of very satisfactory composition, though not quite equal in this respect to two of the specimens from Ebute-Metta owing to the presence of a higher percentage of resin. The biscuits as received contained a larger amount of moisture than is usually present in plantation Para biscuits, but apart from this they compare very favourably in composition with Para rubber from Ceylon and Malaya.

The small consignment of the rubber was offered for sale in London and realised 8*s*. 10¼*d*. per lb., with fine hard Para at 9*s*. 10*d*. per lb. and fine plantation biscuits at 10*s*. 1*d*. to 10*s*. 6*d*. per lb. This price must be considered very satisfactory for such a small lot of rubber. With more practice in making the biscuits in Southern Nigeria the rubber will probably be much improved in appearance, and will then realise a better price if offered in commercial quantities.

Conclusions.

The examination of these specimens of Para rubber from Ebute-Metta and Orugbo has shown that the product is of excellent quality, and quite equal in composition to the plantation Para from Ceylon and Malaya. It is too early to draw any definite conclusions from the results of the tapping experiments, but the yields of rubber so far obtained from Para trees in Southern Nigeria are very promising, and if maintained when tapping is continued through the greater part of the year the returns will be very satisfactory.

The prospects of Para rubber cultivation in Southern Nigeria are therefore very encouraging, and it is hoped that the further experiments now in progress will confirm the favourable results recorded above.

TRINIDAD (1907).

A number of specimens of Para rubber prepared from two trees growing in the Trinidad Botanic Gardens have been examined at the Imperial Institute.

The trees were stated to be from 30 to 35 years old and to be about the same size. Both have been identified as *Hevea brasiliensis*, but it was thought in Trinidad that the rubber they yield is of different quality.

The specimens were as follows: —

No. 1.	Para biscuit from tree	A.	Natural coagulation.
No. 2.	,, ,, ,, ,,	B.	,, ,,
No. 3.	,, ,, ,, trees	A and B (mixed).	,, ,,
No. 4.	,, ,, ,, tree	A.	,, ,,
No. 5.	,, ,, ,, ,,	B.	,, ,,
No. 6.	,, ,, ,, ,,	A.	,, ,,
No. 7.	,, ball ,, ,,	A.	Wound out of cuts daily after collection of latex.
No. 8.	,, ,, ,, ,,	B.	
No. 9.	,, scrap, trees	A and B.	..

The samples were only small so that Nos. 1 and 4 from tree A and Nos. 2 and 5 from tree B were put together for analysis.

Nos. 1 and 4. "Para rubber. Tree A. Age 30-35 years. Natural coagulation." Weight 4 oz.

Two thin biscuits, from 5 to 6 inches in diameter and ⅛ inch thick, with rather rough surface.

The rubber was light reddish-brown, clean, well prepared and free from stickiness; its physical properties were very satisfactory.

The following results were obtained on analysis: —

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·0	—
Caoutchouc	93·0	94·9*
Resin	3·1	3·2
Proteid	1·6	1·6
Ash	0·3	0·3

* Soluble caoutchouc 93·6 per cent.; insoluble caoutchouc 1·3 per cent.

The rubber was valued at 5*s*. 1*d*. per lb. in London, with fine hard Para from South America quoted at 4*s*. 7*d*. per lb. and Para biscuits from Ceylon and the Federated Malay States at 5*s*. 1*d*. to 5*s*. 7½*d*. per lb.

Sample No. 6, also derived from tree A, was a very thin biscuit of pale yellow rubber, weighing about ½ oz. It exhibited good elasticity and tenacity and was quite equal in quality to samples 1 and 4; it was, however, too small for separate examination.

Nos. 2 and 5. "Para rubber. Tree B. Age 30-35 years. Natural coagulation." Weight 7 oz.

Two biscuits of rubber; one 6 inches in diameter and nearly ⅝ inch thick, the other 4 inches in diameter and from ⅛ to ¼ inch thick.

The rubber was light coloured, clean, well prepared, and free from stickiness, but was not quite so strong as the rubber from tree A.

The results of the analysis were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·7	—
Caoutchouc	89·3	92·7*
Resin	3·6	3·7
Proteid	2·6	2·7
Ash	0·8	0·8

* Soluble caoutchouc, 87·4 per cent.; insoluble caoutchouc, 5·3 per cent.

The rubber was valued at 4*s*. 11*d*. per lb. in London on the same date as the preceding specimen.

These samples of rubber from tree B were slightly inferior in physical properties to the specimens prepared from tree A, and the value assigned to the rubber is correspondingly lower. The only noteworthy difference in the composition of the rubber from the two trees is that the product from tree B contains a much higher percentage of "insoluble caoutchouc" than that from tree A.

No. 3. "Para rubber. Latex from trees A and B mixed. Natural coagulation." Weight 4½ oz.

The specimen was a thick biscuit about 5 inches in diameter and from ⅜ to ½ inch thick. The rubber was dark coloured externally but white within, rather porous and moist, and possessed a slight disagreeable odour; it exhibited good elasticity and tenacity. It was not submitted to chemical examination.

Owing to the thickness of the biscuit the rubber had not thoroughly dried, and its moist character adversely affected its market value. The specimen was valued at 4*s*. 3*d*. per lb. in London, on the same date as the preceding specimens.

The investigation showed that the samples of Para rubber prepared in Trinidad are of good quality and would realise very satisfactory prices in the market. From the specimens submitted to the Imperial Institute it would appear that the rubber from tree A is a little better than that yielded by tree B, although the difference is only slight.

Dominica (1909).

The sample was labelled "Small Biscuits of Para Rubber," and weighed 5 oz. It consisted of three biscuits of rubber about 6 inches in diameter and $\frac{1}{16}$ to ⅛ inch thick. The rubber was light-coloured, clean and well prepared; it exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·4	—
Caoutchouc	93·0	93·4
Resin	4·2	4·2
Proteid	2·1	2·1
Ash	0·3	0·3

The sample was valued at 4*s*. 3*d*. per lb. in London, with fine hard Para from South America quoted at 4*s*. 3½*d*. per lb., and plantation Para biscuits at 4*s*. 4*d*. to 4*s*. 11*d*. per lb.

This rubber is of very good quality, and compares favourably in composition with plantation Para rubber from Ceylon and the Federated Malay States.

SAPIUM RUBBER.

A number of trees belonging to the genus Sapium of the Euphorbiaceæ occur throughout the northern part of South America, and some of them yield rubber of good quality. In certain districts of Brazil the latex of species of Sapium appears to be mixed with the latex of the Para tree.

Four species of Sapium are indigenous to British Guiana and one of these, *Sapium Jenmani*, Hemsl., which occurs throughout the forests of the elevated region immediately behind the flat coastal area, furnishes rubber of excellent quality. This fact was established as early as 1884 and since that date small quantities of the rubber, prepared by the natives in the form of ball or scrap, have been exported from the Colony. It is, however, only recently that serious attention has been devoted to *Sapium Jenmani* as a source of rubber, and to the possibility of cultivating it in the Colony. Since 1905 experimental plantations of the trees have been established in several districts throughout the Colony and at the Government Agricultural Experiment Stations, and in most cases the growth has been satisfactory. Tappings of the cultivated trees are now being commenced in order to obtain information as to the yield of rubber which they will furnish and the age at which they will give satisfactory returns; similar experiments are in progress on forest trees.

Although it was known that the rubber of *Sapium Jenmani* was of good quality, no analyses were on record, and at the suggestion of the Imperial Institute authentic specimens were collected in the Colony for examination. The results of the examination of the specimens submitted are given in the following section, and show that the rubber is very satisfactory in composition. A specimen specially prepared in biscuits was found to be of excellent quality, comparing favourably in composition with plantation Para biscuits, and was valued at the same price as fine hard Para.

RUBBER OF *Sapium Jenmani* FROM BRITISH GUIANA (1908-9).

A number of authentic samples of the rubber of *Sapium Jenmani*, together with herbarium specimens of the trees from which they were obtained, have been forwarded for examination to the Imperial Institute by the Department of Science and Agriculture in British Guiana.

I.—The first series of specimens was collected by Mr. J. E. Beckett, of the Agricultural Department, from trees growing on Fort Island and in the neighbourhood of the Arraqua Creek on the Lower Essequibo River.

Six samples of rubber, obtained from six different trees, were submitted for examination. All the trees were described by Mr. Beckett as *Sapium Jenmani*, and his determination has been confirmed at Kew from the botanical specimens which he furnished. One of the trees at Arraqua is described as a forest giant seven feet in circumference three feet from the ground, whilst the others were moderate-sized trees. In addition to the specimens from the Lower Essequibo River, Mr. Beckett also sent two balls of rubber collected in 1906 from *Sapium Jenmani* trees in the Pomeroon District.

Description of Samples.

No. 1. Five small "biscuits" of rubber weighing 65 grams, and two pieces of "scrap" rubber weighing 140 grams.

The biscuits were light brown, whilst the scrap varied from yellow to brown; a little vegetable impurity was present. The rubber exhibited fair elasticity and tenacity.

No. 2. Seven small biscuits weighing 77 grams, and one piece of scrap rubber weighing 55 grams.

Both biscuits and scrap rubber were very similar to No. 1 in general appearance and properties, but were darker in colour and the rubber was slightly sticky.

No. 3. Four small biscuits weighing 40 grams, and one piece of scrap rubber weighing 45 grams.

They were very similar to No. 1, but darker in colour.

No. 4. One very thin biscuit weighing 8 grams, and two pieces of scrap rubber weighing 146 grams.

The biscuit consisted of rather weak brown rubber; the scrap rubber was similar to No. 1, but a little darker in colour.

No. 5. Four small biscuits weighing 63 grams, and three pieces of scrap rubber weighing 230 grams.

They were very similar to No. 1, but inclined to be slightly sticky.

No. 6. Eight small biscuits weighing 165 grams, and two pieces of scrap rubber weighing 270 grams.

They were very similar to No. 1, but darker in colour.

Ball rubber.—Two balls weighing 211 grams, black externally but white and moist within when freshly cut. The rubber exhibited only fair elasticity and tenacity.

Samples 1 to 6 were all very similar in appearance and properties, the only differences being a small variation in colour and a slight stickiness in two of the specimens (Nos. 2 and 5). The rubber was inclined to be weak and tore easily when stretched.

Results of Examination.

Four of the specimens, Nos. 1, 5, 6 and one of the balls, were examined chemically for comparison, the "biscuits" being analysed in the first three cases as representing the rubber in its purest form. The following percentage results were obtained:—

	Rubber as received.				Composition of dry rubber.			
	No. 1.	No. 5.	No. 6.	Ball.	No. 1.	No. 5.	No. 6.	Ball.
Moisture	2·3	1·7	6·8	19·2	—	—	—	—
Caoutchouc	85·1	86·4	83·7	72·2	87·1	87·9	89·8	89·3
Resin.	2·7	3·5	3·4	3·4	2·8	3·6	3·7	4·2
Proteid	5·7	4·9	4·6	2·0	5·8	4·9	4·9	2·5
Insoluble matter ...	4·2	3·5	1·5	3·2	4·3	3·6	1·6	4·0
Ash	1·33	0·81	1·81	0·95	1·38	0·82	1·99	1·18

A consideration of these figures shows that the rubber is of very good quality so far as chemical composition is concerned.

The percentages of caoutchouc are high, ranging from 87·1 to 89·8 per cent. on the dry rubber, whilst the amounts of resin are low. The figures for proteid are a little high in the case of samples Nos. 1, 5 and 6, but curiously enough the amount of this constituent present in the ball rubber is only half that found in the other specimens.

Commercial Values.

The specimens were submitted for valuation to brokers with the following results:—

		Per lb.
Scrap (Lace) rubber	No. 1	2*s.* 10*d.*
,, ,,	Nos. 2, 3, 4 and 5 ...	2*s.* 8*d.*
,, ,,	No. 6	3*s.* 0*d.*
Ball rubber	... ...	2*s.* 6*d.*

The biscuits were rather small for separate commercial valuation, but the different samples were very similar in quality, and a price of 3*s.* 6*d.* per lb. was quoted for the rubber in this form if in good condition. A few of the biscuits were inclined to be sticky, and for this reason would realise only about 2*s.* per lb. At the date of these valuations, fine hard Para rubber from South America was quoted at 3*s.* 5½*d.* per lb. in London, and fine plantation Para at 3*s.* 11*d.* to 4*s.* 4½*d.* per lb.

II.—A second collection of specimens was procured by Mr. R. Ward, the Agricultural Superintendent in British Guiana, from the North-West District of the Colony.

Description of Samples.

No. 1. Three blocks of scrap rubber, together weighing 9¼ lb., which were stated to have been prepared by Indians in a district where *Sapium Jenmani* is plentiful, and were therefore probably pure specimens of the rubber of this tree.

These consisted of flat blocks of rubber made up of aggregated shreds, varying in colour from light to dark brown. The rubber was fairly free from vegetable impurity, but was not very strong.

No. 2. Two balls of rubber also collected by Indians, one being a good specimen and the second highly sticky.

The former weighed 15 oz., and had been formed from thin strips of rubber. It was fairly homogeneous, dark brown externally, but white and moist within when freshly cut. The rubber exhibited only fair elasticity and tenacity.

The second ball weighed 12 oz. It had evidently been overheated during preparation or subsequently.

No. 3. Eight samples of rubber obtained by Mr. Ward from different specimens of *Sapium Jenmani*, found at Mount Terminus, Barima River.

These specimens consisted of scrap rubber aggregated into small cakes or sheets and closely resembled the lace rubber collected by the Indians.

Botanical specimens of the trees which furnished the samples of rubber were forwarded, and the identification of the trees as *Sapium Jenmani* has been confirmed at Kew.

No. 4. A botanical specimen of a tree believed to be *Sapium paucinervium*, Hemsl., was also forwarded, and has been pronounced at Kew to belong to that species. It is said to yield a thin watery latex of no commercial value.

Results of Examination.

The specimens of lace and ball rubber collected by the Indians and one of the samples collected by Mr. Ward have been examined with the following percentage results:—

—	Rubber as received.			Composition of dry rubber.		
	Lace rubber collected by Indians. No. 1.	Ball rubber collected by Indians. No. 2.	Lace rubber No. 6 tree. No. 3.	Lace rubber collected by Indians. No. 1.	Ball rubber collected by Indians. No. 2.	Lace rubber No. 6 tree. No. 3.
Moisture	2·6	8·4	1·1	—	—	—
Caoutchouc	87·3	80·6	91·4	89·6	88·0	92·4
Resin	2·4	2·4	2·0	2·5	2·6	2·0
Proteid	4·4	4·2	2·8	4·5	4·6	2·8
Insoluble matter ...	3·3	4·4	2·7	3·4	4·8	2·7
Ash	1 23	1·04	0·68	1·26	1·13	0·69

A comparison of these figures with the results of the analyses of the previous specimens shows that the two sets of rubbers are very similar in composition. The rubber collected by Mr. Ward (No. 6 tree) contains the highest percentage of caoutchouc and the lowest percentage of resin in the series, whilst the amount of proteid is much lower than in any of the samples except the ball rubber of the previous set.

Commercial Values.

The specimens were submitted to brokers at the same time as the series collected by Mr. Beckett. The lace rubber collected by the Indians and also the specimens prepared by Mr. Ward were valued at 2*s*. 4½*d*. per lb. in London, whilst 2*s*. 5*d*. per lb. was quoted for the ball rubber. The value of the lace rubber is a little lower than the prices quoted for the first set of specimens, probably owing to its darker colour.

III.—Several specimens of the rubber of *Sapium Jenmani* were shown at the International Rubber Exhibition held in London in September, 1908, and were afterwards transferred to the Imperial Institute. One of the samples had been specially prepared by Mr. C. Wilgress Anderson of the Forestry Department, who spent some time at the Imperial Institute in 1908 studying the questions of the collection and preparation of rubber. This specimen has been examined chemically for comparison with the samples already described.

The sample was labelled:—"No. 1. Biscuits from latex of *Sapium Jenmani*, Hemsl., prepared and exhibited by C. Wilgress Anderson, Forestry Officer." It consisted of thin biscuits of very pale amber rubber, excellently prepared, and in good condition. The rubber exhibited very good elasticity and tenacity.

The chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·7	—
Caoutchouc	93·7	94·4
Resin	1·8	1·8
Proteid	3·2	3·2
Ash	0·6	0·6

The rubber was valued at 4*s*. 3*d*. per lb. in London, with fine hard Para from South America quoted at 4*s*. $3\frac{1}{2}$*d*. per lb., and plantation Para biscuits at 4*s*. 4*d*. to 4*s*. 11*d*. per lb.

This specimen of *Sapium Jenmani* rubber is much superior in physical properties to the samples previously examined and the analytical figures are also better.

Conclusions.

The results of the investigations show that so far as chemical composition is concerned the rubber of *Sapium Jenmani* is of good quality, and there is no doubt that if carefully prepared it will realise satisfactory prices in the market. There is a little variation in the amounts of resin, proteid and insoluble matter present in the different samples collected by Mr. Beckett and Mr. Ward, but the percentage of caoutchouc is fairly uniform throughout, and in the case of No. 6 of the second series reaches 92·4 per cent. These specimens are generally inclined to be rather weak and in some cases are slightly sticky, both of which features tend to reduce the market value.

The biscuits prepared by Mr. Anderson are of excellent quality both as regards composition and physical properties, comparing favourably with Para plantation biscuits in these respects.

CEARÁ RUBBER.

Manihot Glaziovii, Muell. Arg.

This tree, which furnishes the rubber known as Maniçoba in South America, is a native of north-eastern Brazil, principally in the State of Ceará. It occurs wild under a wide range of conditions, being found on the dry desert plains where the rainfall is less than 50 inches per annum and the vegetation is scorched for the greater part of the year, and also on the hill sides up to elevations of 3,500 feet with a rainfall of over 100 inches per annum and a night temperature below 60° F. The tree appears to thrive best on poor scanty soil.

Manihot Glaziovii belongs, like the Para tree, to the natural order Euphorbiaceæ. It is a moderate-sized tree, 30 to 50 feet in height with an erect trunk 8 to 20 inches in diameter. As a rule the branches are numerous and spreading, forming a dense rounded crown, but in some trees only a few erect branches are developed.

The tree is very hardy and of quick growth, and the seeds, which are produced very freely, retain their vitality for a considerable time. As a result of these characteristics the Ceará tree has been introduced into nearly every tropical country, and it has been cultivated on a fairly extensive scale in Ceylon, Southern India and latterly in East Africa. Plantations of the tree have also been established in Brazil.

The Ceará tree does not stand tapping so well as the Para tree, and the yield of rubber is usually lower. It offers the advantage, however, that it can be grown in dry situations where the Para tree will not thrive, and the introduction of improved methods of tapping has greatly increased its value for purposes of cultivation. The tree promises to do well in the dry regions of East Africa.

In some countries the latex of the Ceará tree flows freely, so that it can be collected in bulk. The rubber can then be obtained by diluting the latex with water and allowing it to stand, with or without the addition of acetic acid. In other cases the latex does not flow readily, but coagulates quickly on the trunk of the tree, and the rubber is collected in the form of scrap or ball.

Ceará rubber, if carefully prepared, is of excellent quality, and specimens from Ceylon have realised prices equal to those of fine plantation Para. The Maniçoba rubber exported from Brazil is frequently of low value on account of the defective methods of preparation employed, which lead to the inclusion in the rubber of considerable amounts of impurities.

Specimens of Ceará rubber have been forwarded to the Imperial Institute for examination from India, Ceylon, the Gold Coast, Southern Nigeria, the Sudan, Uganda, East Africa Protectorate, Nyasaland, Rhodesia and Portuguese East Africa.

INDIA.

I.—*Ceará Rubber from Nilambur, Beypore* (1903).

The sample consisted of thin circular cakes of dark brown rubber, ranging up to 5 inches in diameter and about ¼ inch in thickness.

They were rather dirty on the surface, covered with mould, and possessed a strong disagreeable odour. The rubber appeared to have undergone slight deterioration, presenting the appearance of partially perished rubber, and it was deficient both in elasticity and tenacity.

A chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·6	—
Caoutchouc	86·2	89·4
Resin	3·2	3·3
Insoluble matter ...	7·0	7·3
Ash	3·0	3·1

The results show that the rubber is of very fair quality, the percentage of resin present being small, although the amount of insoluble impurity is excessive. Unfortunately the physical properties were not correspondingly satisfactory.

The specimen was valued at about 2*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 2*d*. per lb.

II.—*Ceará Rubber from South Arcot, Madras* (1908).

The sample weighed 3½ oz. and consisted of pale rubber, which was clean and exhibited good elasticity and tenacity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·4	—
Caoutchouc	73·7	76·3*
Resin	4·6	4·7
Proteid	16·0	16·6
Ash	2·3	2·4

* Soluble caoutchouc 69·3 per cent.; insoluble caoutchouc 7·0 per cent.

The specimen was valued at 2*s*. 5*d*. per lb. in London, with fine hard Para from South America quoted at 3*s* 5½*d*. per lb.

The rubber contains a high percentage of proteid and a considerable amount of "insoluble" caoutchouc, both of which features, however, are not uncommon in Ceará rubber.

III.—*Ceará Rubber from Kullar, Nilgiris* (1908).

This rubber was prepared at Kullar, and bore the following label:—

"No. 1. Ceará rubber from trees planted in the Government Experimental Garden, Kullar (1,300 feet), Nilgiris, in April, 1902; collected February, 1908." It weighed 9 oz., and consisted of six biscuits of pale amber rubber, clean and well prepared. The physical properties of the rubber were very good.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·8	—
Caoutchouc	80·2	82·5*
Resin	6·2	6·4
Proteid	9·5	9·8
Ash	1·3	1·3

* Soluble caoutchouc 76·5 per cent.; insoluble caoutchouc 6·0 per cent.

The rubber was valued at 5*s.* 6*d.* per lb. in London, with fine hard Para from South America quoted at 5*s.* 1*d.* per lb., and plantation Para biscuits at 5*s.* 3*d.* to 5*s.* 9*d.* per lb.

This Ceará rubber is of very good quality, although the percentages of resin and proteid are rather high. The biscuits varied somewhat in colour, and it would be an advantage if they could be obtained more uniform in this respect.

Ceylon.

Ceará Sheet from Ceylon (1910).

The specimen weighed 10 oz. and consisted of three square sheets of light-brown opaque rubber, clean and well-prepared, but a little mouldy on the surface. The physical properties of the rubber were very satisfactory.

A chemical examination gave the following results:—

	Per cent.
Moisture	0·9
Caoutchouc	91·3†
Resin	3·1
Proteid	3·4
Ash	1·3

† Including 2·9 per cent. of "insoluble caoutchouc."

The specimen was valued at probably about 8*s.* per lb. in London, with fine hard Para at 10*s.* per lb. and good to fine plantation Para biscuits at 8*s.* 10½*d.* to 9*s.* per lb.

This rubber is of good quality and satisfactory in composition except that the amount of ash is unusually high.

Gold Coast.

Ceará Rubber from Aburi (1906).

This sample was prepared from trees growing in the Botanic Gardens at Aburi. It consisted principally of loosely aggregated shreds of rubber, together with a few small compact pieces. The rubber was light brown, free from vegetable impurity, and exhibited very fair elasticity and tenacity.

It furnished the following results on analysis:—

	Per cent.
Moisture	4·4
Caoutchouc	67·7
Resin	4·4
Proteid	20·4
Ash	3·1

The only noteworthy feature of the analytical results is the large amount of proteid present, but this is not uncommon in the case of Ceará rubber. The percentage of resin is low.

The rubber was submitted for commercial valuation to brokers, who described it as good pale Ceará rubber of scrap character. They considered that material equal to the sample would probably realise 3*s*. 6*d*. per lb. in London, with fine hard Para rubber from South America quoted at 5*s*. 4*d*. per lb.

SOUTHERN NIGERIA.

I.—*Ceará Rubber from Lagos* (1905).

The specimen consisted of about 3 oz. of rubber in irregular lumps, which had been formed by the aggregation of very small balls. The rubber was light brown and free from visible impurity. Its physical characters were not very satisfactory, as the greater part of the sample appeared to be slightly perished, especially on the outside of the lumps, and the rubber was very deficient in elasticity and tenacity.

The rubber was found to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	6·4	—
Caoutchouc	62·8	67·2
Resin	3·4	3·6
Proteid	22·4	23·9
Insoluble matter ...	5·0	5·3
Ash	2·6	2·7

The striking feature of the analytical results is the large amount of proteid contained in the rubber. The presence of this excessive quantity has probably arisen through the immediate coagulation of the latex as it issued from the tree, whereby the whole of the proteid in the latex was included in the rubber.

The rubber was submitted for valuation to brokers, who described it as rather stringy and perished scrap, and valued it at about 2*s* 9*d*. per lb., with fine hard Para quoted at 5*s*. 7*d*. per lb.

The investigation showed that this sample of Ceará rubber was unsatisfactory both as regards physical properties and chemical composition, and that it would consequently fetch only a low price in the market.

II.—*Ceará Rubber prepared by the Lewa Method and afterwards Smoked* (1910).

The sample weighed 10 lb. and consisted of cakes of rubber formed of aggregated balls which were rather moist internally and contained a little vegetable impurity. The rubber was dark brown externally but white within, and had a strong smoky odour; it was rather deficient in strength.

The results of the examination were as follows:—

	Per cent.
Loss on washing (moisture and impurities)	21·7
Composition of dry washed rubber:—	
Caoutchouc	84·1
Resin	7·8
Proteid	6·5
Ash	1·6

The value of consignments of rubber similar to this sample is uncertain, but would probably be from 4*s*. to 4*s*. 6*d*. per lb. in London, with fine hard Para quoted at 6*s*. 11*d*. per lb.

This rubber is only of fair quality on account of its deficient strength. The large loss on washing is due primarily to the moist condition of the rubber. The percentages of resin, proteid and ash are all rather high.

If the latex flows sufficiently freely from the trees to be collected in bulk it would be advisable to prepare the rubber in the form of biscuits by diluting the latex and allowing it to stand. This method would probably reduce the amount of proteid present in the rubber.

The appearance of this sample of rubber was greatly improved by converting it into crêpe by means of a washing machine.

SUDAN.

Rubber from Ceará Plantations in Mongalla (1910).

The sample consisted of five biscuits of pale yellow rubber which were clean, well-prepared, and free from impurities. The rubber exhibited good elasticity and tenacity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·2	—
Caoutchouc	80·1	81·9
Resin	5·8	5·9
Proteid	9·8	10·0
Ash	2·1	2·2

The specimen was valued at 4*s*. 10*d*. per lb. in London, with fine hard Para at 5*s*. 10*d*. per lb, and good to fine plantation Para biscuits at 5*s*. 1*d*. to 5*s*. 4½*d*. per lb.

This rubber, derived from two-year-old trees, is of very good quality, and its preparation is quite equal to that of any Ceará rubber on the market. In composition it is not quite so good as some specimens of plantation Ceará from Ceylon, but it is superior to samples from East Africa which have been examined at the Imperial Institute.

The results of this investigation are very promising, and indicate that the Ceará trees at Mongalla may be expected to furnish rubber of very good quality.

UGANDA.

I.—*Ceará Rubber coagulated with Lime Juice, and a very weak solution of Formaldehyde added as a Preservative* (1910).

The sample weighed 1½ lb. and consisted of thin biscuits of pale yellow rubber, very uniform in colour, and excellently prepared. The physical characters of the rubber were very satisfactory.

The chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·8	—
Caoutchouc	72·8	76·5
Resin	7·6	8·0
Proteid	11·9	12·5
Ash	2·9	3·0

The rubber was valued at from 8*s*. 2*d*. to 8*s*. 4*d*. per lb. in London, with fine hard Para at 10*s*. 1*d*. per lb., and good to fine plantation Para biscuits at 8*s*. 10¼*d*. to 9*s*. per lb.

This Ceará rubber is of very good quality, and its preparation leaves little to be desired. The results of the analysis show, however, that the percentages of resin, proteid, and ash, are all high, the amounts of the two latter constitutents being much greater than is usual in biscuit Ceará rubber.

It is difficult to account for the large percentage of proteid (12·5) present in the rubber, unless it is to be attributed to the method of preparation employed. It was suggested that it would be desirable to prepare, for comparative analysis, a few biscuits of the rubber by simply diluting the latex with water and allowing it to stand without any other addition.

II.—*Ceará Rubber prepared with Water Only* (1910).

This sample of Ceará rubber was prepared in response to the suggestion contained in the preceding report. It weighed 1¼ lb. and consisted of three pieces of corrugated sheet rubber about ¼ inch thick, which were rather moist when received. The rubber was light yellow externally but quite white within, and free from vegetable impurities; its physical properties were very satisfactory.

A chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·5	—
Caoutchouc	86·1	89·3
Resin	5·7	5·9
Proteid	3·6	3·7
Ash	1·1	1·1

The rubber was valued at 4*s*. 3*d*. per lb. in London, with fine hard Para quoted at 5*s*. 2*d*. per lb.

This specimen of Ceará rubber is much superior in composition to the previous sample. The percentages of resin, proteid, and ash are all much lower, and the amount of caoutchouc consequently greater. It appears, therefore, that the method of coagulating the latex by simply adding water and allowing it to stand will give a much purer rubber than the process adopted in the previous case.

East Africa Protectorate.

I.—*Ceará Rubber from the Kibos District* (1908).

The specimen weighed $2\frac{1}{2}$ oz., and consisted of a small ball of pale brown rubber which was very moist internally when freshly cut. The rubber was slightly sticky and exhibited fair elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	12·4	—
Caoutchouc	58·9	67·2
Resin	10·5	12·0
Proteid	12·1	13·8
Insoluble matter ...	6·1	7·0
Ash	2·4	2·8

The sample was too small for trustworthy valuation, but rubber of similar quality would probably realise about 3*s.* per lb. in London, with fine hard Para quoted at 4*s.* $3\frac{1}{2}$*d.* per lb.

The percentages of resin, proteid, and insoluble matter present in this rubber are all rather excessive. These defects may, however, be due in part to the fact that the latex coagulated spontaneously in the incisions, and the rubber would, therefore, include practically the whole of the resin and proteid present in the latex.

II.—*Ceará Rubber from Kisumu* (1909).

This sample was stated to have been obtained from Ceará trees about 18 months old at the Mill Hill Park Mission Station near Kisumu. It consisted of a small ball of light brown rubber, rather sticky externally and moist within. The rubber exhibited poor elasticity and tenacity.

An analysis showed the rubber to have the following composition:—

	Rubber as received. Per cent.	Composition of dry material. Per cent.
Moisture	10·0	—
Caoutchouc	59·8	66·4
Resin	8·7	9·7
Proteid	13·9	15·5
Insoluble matter ...	7·6	8·4
Ash	4·02	4·46

The sample was too small for trustworthy valuation, but rubber of similar character would possibly realise about 3*s.* per lb. in London, with fine hard Para at 5*s.* per lb.

The rubber is of inferior quality on account of the large amounts of resin, proteid, and insoluble matter present, which adversely affect its physical properties. It must, however, be borne in mind that the rubber was derived from very young trees, and that the quality may improve as the trees become older.

NYASALAND.

I.—*Ceará Rubber from Zoa* (1905).

The following particulars were furnished regarding this specimen of rubber:—

"The trees (*Manihot Glaziovii*), utilised for the experiments, were planted at Zoa some ten or twelve years ago, and were practically growing wild, having received no attention whatever during the last six or seven years. Many of the trees were badly attacked by white ants, some of the stems being completely riddled by these pests. The trees were growing in a loose black soil at an elevation of some 1,500 feet above the sea-level, the average rainfall being about 35 inches per annum."

The specimen submitted for examination consisted of a number of balls of dark reddish-brown rubber; the whole sample weighed about 14 oz. The rubber was slightly sticky and soft, and though very tenacious it was only moderately elastic.

The sample was analysed with the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	10·4	—
Caoutchouc	65·5	73·4
Resin	4·8	5·3
Proteid	14·9	16·6
Insoluble matter ...	4·4	4·7
Ash	3·7	4·1

These results show that this specimen of Ceará rubber is of fair quality, though the percentages of proteid and insoluble matter are rather high.

The rubber was valued at from 2*s*. 9*d*. to 3*s* per lb. in London, with fine hard Para quoted at 5*s*. 1*d*. to 5*s*. 2*d*. per lb.

II.—*Ceará Biscuits from Nyasaland* (1909).

This sample of Ceará rubber weighed 7½ oz., and consisted of five biscuits of pale rubber, which was clean and well-prepared. The rubber exhibited very good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·2	—
Caoutchouc	85·1	86·1
Resin	6·7	6·8
Proteid	6·1	6·2
Ash	0·9	0·9

The sample was submitted to brokers, who valued it at 5*s*. 4*d*. per lb. in London, with fine hard Para from South America at 5*s*. 4*d*. per lb., and fine plantation Para biscuits at 5*s*. 4¾*d*. to 5*s*. 5¾*d*. per lb.

The results of the analysis show that this rubber is of satisfactory composition, although the percentages of resin and proteid are higher than those recorded for some specimens of Ceará rubber from Ceylon. The sample compares very favourably both in appearance and composition with specimens of Ceará rubber from Portuguese East Africa which have been examined at the Imperial Institute.

The rubber contained a quantity of the so-called insoluble caoutchouc, which was white and very tenacious when dry.

Consignments of similar character to this sample would always be readily saleable at good prices.

III.—*Ceará Rubber prepared from Two-year-old Trees by Pricking* (1910).

The sample consisted of very small balls of light brown rubber, the average weight of a single ball being 1·08 gram. Some of the balls were moist internally, and a little vegetable impurity was present. The rubber exhibited fair elasticity and tenacity.

The results of the chemical examination were as follows:—

Loss on washing (moisture and impurities) 4·9 per cent.

Composition of dry washed rubber:—

	Per cent.
Caoutchouc	78·6
Resin	10·8
Proteid	8·4
Ash	2·2

The rubber was submitted to brokers, who valued it at about 5*s* per lb. in London, with fine hard Para at 10*s*. 6*d*. per lb.

The rubber contained a high percentage of resin, but as it was derived from trees only two years old, this feature is not surprising. The amount of proteid is also excessive.

It will be seen that the value of this sample of Ceará rubber was placed at about half that of fine hard Para, whereas Ceará biscuits from Nyasaland have realised prices equal to that of fine hard Para. If, however, the rubber were less resinous than this specimen, there is no doubt that the balls would fetch a better price than the present quotation, and it would be of interest to tap a number of mature trees by the pricking process and forward the rubber obtained for examination and valuation.

The rubber obtained from two-year-old trees, if similar to the present sample, would, however, be saleable, and provided that the pricking at this early age does not damage the trees, there is no reason why the method should not be adopted.

The relative values of the pricking and herring-bone systems of tapping Ceará trees, as regards the yield and value of the rubber obtained and the effect upon the trees, will have to be determined by experiments in Nyasaland. The chief objection to the pricking method is that the rubber is obtained in balls or as "scrap," but the use of a washing machine would obviate this drawback.

Rhodesia.

I.—*Ceará Rubber from Southern Rhodesia* (1904).

This sample of Ceará rubber was obtained from trees 4½ years old in Southern Rhodesia. It consisted of a small ball of greyish-brown rubber which was soft, rather moist, and somewhat sticky; it exhibited moderate elasticity and tenacity.

On analysis it was found to have the following composition:—

	Per cent.
Moisture	5·5
Caoutchouc	66·6
Resin	7·4
Insoluble matter	20·5
Ash	2·0

The specimen was too small for trustworthy valuation, but consignments of similar character would probably realise from 2*s.* to 2*s.* 3*d.* per lb., with fine hard Para quoted at about 5*s.* per lb.

The specimen contained a large quantity of insoluble matter and a high percentage of ash.

II.—*Ceará Rubber from North Eastern Rhodesia* (1908).

This specimen was labelled as follows: "Ceará rubber from Mirongo, North Eastern Rhodesia; from four trees about four years old." It weighed about 9½ oz. and consisted of a large number of small balls of rubber ranging from ½ to 1½ inch in diameter. The balls were brown externally, but white and moist within; they contained a considerable quantity of sand and possessed a very disagreeable odour. The elasticity and tenacity of the rubber were fairly good.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·5	—
Caoutchouc	55·8	61·6
Resin	6·7	7·4
Proteid	11·1	12·3
Ash	16·9	18·7

The rubber was valued at 1*s.* 8*d.* per lb. in London, with fine hard Para quoted at 3*s.* 5½*d.* per lb.

This sample of rubber was of inferior quality on account of the large percentage of sand which it contained. Care should be taken to exclude this impurity as its presence detracts considerably from the value of the rubber.

Portuguese East Africa.

I.—*Ceará Rubber from Guara-Guara* (1908).

These samples of Ceará rubber were prepared by the Director of Agriculture for the Companhia de Moçambique, in the course

of his experimental tappings of Ceará trees at the Guara-Guara and Massanzane Estates Company's plantation in Portuguese East Africa, the details of which were given in a report published in the *Bulletin of the Imperial Institute* (1907, **5**. 401).

Eleven samples of rubber, prepared by slightly different processes, were submitted for examination, and the following details were furnished regarding their preparation:—

No. 1 (2 biscuits).—A solution of 1 per cent. ammonia placed in collecting cups.

No. 2 (2 biscuits).—A solution of 2 per cent. ammonia placed in collecting cups.

No. 3 (3 biscuits).—A solution of 2 per cent. ammonia placed in collecting cups. 1 per cent. solution of creosote added to latex.

No. 4 (3 biscuits).—1 per cent. solution of formaldehyde placed in collecting cups. Rubber smoked.

No. 5 (2 biscuits).—2 per cent. solution of formaldehyde placed in collecting cups. Rubber smoked.

No. 6 (6 biscuits).—3 per cent. solution of formaldehyde placed in collecting cups. Rubber smoked.

No. 7 (3 biscuits).—4 per cent. solution of formaldehyde placed in collecting cups. Rubber smoked.

No. 8 (3 biscuits).—5 per cent. solution of formaldehyde placed in collecting cups. Rubber smoked.

No. 9 (2 biscuits).—Rubber smoked.

No. 10.—Smoked "scrap."

No. 11.—"Scrap."

The unsmoked biscuits, Nos. 1, 2, and 3, were very similar in appearance. They consisted of thin biscuits of pale brown rubber, rather rough and with white patches on the surface. The physical properties of all three samples were satisfactory.

The smoked specimens, Nos. 4, 5, 6, 7, 8, and 9, were also very similar in character. They were dark brown, but were otherwise superior in appearance to the unsmoked samples; they had a strong smoky odour. The physical properties of all the specimens were very satisfactory, and no differences could be detected between the samples prepared with varying amounts of formaldehyde.

The scrap rubbers, Nos. 10 and 11, were of good quality, the only difference being that the smoked sample, No. 10, was darker than the unsmoked scrap.

Results of Examination.

The following four samples, representative of the entire collection, were selected for analysis:—

No. 1.—1 per cent. solution of ammonia added to latex.

No. 3.—2 per cent. solution of ammonia and 1 per cent. solution of creosote added to latex.

No. 4.—1 per cent. solution of formaldehyde added to latex; rubber smoked.

No. 8.—5 per cent. solution of formaldehyde added to latex; rubber smoked.

The results of the examination of these samples are given in the following table:—

—	Rubber as received.				Composition of dry rubber.			
	No. 1.	No. 3.	No. 4.	No. 8.	No. 1.	No. 3.	No. 4.	No. 8.
Moisture, per cent....	1·9	2·9	0·6	1·7	—	—	—	—
Caoutchouc, per cent.	82·9	80·3	85·1	83·1	84·4*	82·8*	85·6*	84·6*
Resin, per cent. ...	5·7	5·3	6·3	6·7	5·8	5·5	6·3	6·8
Proteid, per cent. ...	8·1	9·1	6·1	6·9	8·3	9·4	6·2	7·0
Ash, per cent. ...	1·4	2·2	1·9	1·6	1·5	2·3	1·9	1·6

* "Caoutchouc" insoluble in chloroform 1·0 1·6 0·7 0·2

It will be seen from a comparison of these figures that the four samples of Ceará rubber are fairly uniform in composition. The percentages of caoutchouc in the dry rubbers show little variation in the case of Nos. 1, 4 and 8; whilst the amount in No. 3 is only slightly lower than in the other samples owing to the presence of larger quantities of proteid and ash. All the specimens contained a small amount of "caoutchouc" insoluble or difficultly soluble in chloroform, the percentages of this constituent ranging from 0·2 in No. 8 to 1·6 in No. 3. The amounts of resin and ash vary a little in the different samples, but in no case are they excessive. The proteid figures are, however, a little high, especially in Nos. 1 and 3. It must be remembered, however, that ammonia was used in the preparation of samples Nos. 1 and 3, and this fact no doubt explains the higher percentage of nitrogen (from which the amount of proteid is calculated) found in these two cases. It may be noted further that No. 3, in which 2 per cent. ammonia was employed, gave a higher result than No. 1, where only 1 per cent. solution of ammonia was used. Except for this variation in the proteid figures, there is little difference between the results obtained for Nos. 1 and 3, and similarly Nos. 4 and 8, prepared with 1 and 5 per cent. solution of formaldehyde respectively, show only slight variation in composition.

It was not stated whether these different samples of rubber were all prepared from a bulked quantity of latex, so as to permit of direct comparisons being made between the different methods of preparation employed, or whether the samples represent the product of the separate groups of trees. The variations in the analytical figures are, however, such as would be likely to occur in specimens prepared from different trees.

The results of the chemical examination of these four samples are satisfactory, and indicate that Ceará rubber of good quality can be prepared in the territory of the Mozambique Company.

For comparison with the results obtained in the examination of these samples of Ceará rubber from Portuguese East Africa, the following figures giving the composition of Ceará rubber produced in Ceylon may be quoted:—

—	I.	II.	III.
Moisture, per cent.	0·70	3·10	1·58
Caoutchouc " "	92·58	87·97	86·14
Resin " "	3·80	1·40	5·74
Proteid " "	2·12	6·13	5·06
Ash " "	0·80	1·40	1·48

These Ceylon samples show striking differences in the percentages of resin and proteid, but all of them are slightly superior in composition to the specimens from Portuguese East Africa.

Commercial Value.

The following report on the commercial value of the samples in London has been furnished by brokers, and for comparison with the prices quoted it may be stated that fine hard Para rubber from South America was valued at 4*s.* 1*d.* per lb. on the same date, and fine plantation Para at 4*s.* 7*d.* to 4*s.* 8½*d.* per lb.

No. 1 (two biscuits cured by 1 per cent. ammonia solution in collecting cups).—Light and dark amber Ceará biscuits, rather rough, and a little stained.

No. 2 (two biscuits, 2 per cent. ammonia).—About the same as No. 1, but rather dull.

No. 3 (three biscuits, 2 per cent. ammonia and 1 per cent. solution of creosote).—Similar to above, but rather rough and scaly.

These three lots are of good quality and well prepared, there being very little to choose between them; if anything, No. 1 is rather the best. Value 4*s.* 6*d.* per lb.

No. 4 (three biscuits, 1 per cent. of formaldehyde).—Dark amber biscuits, good quality; one biscuit slightly deadish, not properly cured. Value 4*s.* 6*d.* per lb.

Nos. 5, 6, 7 and 8 (cured with 2, 3, 4 and 5 per cent. solution of formaldehyde placed in collecting cups).—All good dark amber biscuits, well prepared; clear, clean and strong. Value 4*s.* 7*d.* per lb.

No. 9 (two biscuits, smoke cured).—A little rough, but apparently quite as good and well prepared as Nos. 5 to 8. Value 4*s.* 7*d.* per lb.

The smoked biscuits are better in appearance, and seem rather more resilient than the unsmoked. As to the effect on the rubber of ammonia and formaldehyde in various quantities, this would have to be determined by analysis, or on the reports of manufacturers, as the samples themselves show very little difference, whether mixed with 1 per cent. or 5 per cent.

No. 10.—Good clean brown smoked Scrap, free from heat, and well cured. Value 3*s.* 6*d.* per lb.

No. 11.—Pale Ceará Scrap, free from bark and heat, and of the usual quality of the grade. Value 3*s.* 4*d.* to 3*s.* 5*d.* per lb.

Conclusions.

It is evident from the results of this investigation that Ceará rubber of very satisfactory quality and value can be produced in Portuguese East Africa. It now remains to ascertain the yield of rubber obtainable from the trees by the use of improved methods of tapping.

II.—*Ceará Rubber from Chibaba and Maruma* (1908).

"No. 1. Ceará rubber collected in Chibaba plantation."

The specimen consisted of three small thin biscuits of rubber which together weighed only $\frac{2}{3}$ oz. The rubber was dark-coloured and of rather rough appearance, but exhibited very satisfactory physical properties.

The sample was too small for chemical examination but the rubber was evidently of good quality. It was valued by brokers at 4*s*. 6*d*. per lb. with fine hard Para from South America quoted at 4*s*. 2*d*. per lb., and Para biscuits from Ceylon at 4*s*. 10*d*. per lb.

"No. 2. Ceará rubber from the Maruma estate."

A single biscuit of rubber weighing less than 1 oz. The rubber was darker in colour than the previous specimen and of rather rough appearance, but strong and of good quality. The sample was too small for chemical examination. It was valued by brokers at 4*s*. 4*d*. per lb.

These two specimens of Ceará rubber compare very favourably in physical properties with the samples from Guara-Guara, but were rather darker in colour. Owing to the smallness of the samples it was, however, impossible to determine their composition for comparison.

CASTILLOA RUBBER.

Castilloa elastica, Cerv.

The Castilloa tree is a native of Central America, its habitat extending from Mexico, south of 22° N. latitude, into Colombia; it also occurs on the western slopes of the Andes, in Ecuador and Peru. It is a large forest tree belonging to the natural order Moraceæ and grows naturally at low elevations, being seldom found higher than 2,000 feet above the sea level; it occurs most abundantly on the banks of rivers or streams and on moist plains where there is good drainage, but it will not grow on swampy land. The Castilloa tree is found under a wide range of climatic conditions in Central America and a number of distinct varieties have been described from different districts.

Large plantations of Castilloa trees have been established in Mexico and also to a smaller extent in the States of Central America, including British Honduras, and in Colombia and Ecuador. The trees have also been tried experimentally in India and Ceylon, the British Colonies and Protectorates in East and West Africa, and in the West Indies. The tree has not succeeded very well under cultivation outside its natural habitat, and so far as the British Colonies are concerned, it is only in British Honduras and the West Indies that *Castilloa elastica* is likely to be extensively grown.

The latex from young Castilloa trees up to 8 years old usually contains a large proportion of resin, and therefore furnishes inferior rubber; the trees should therefore not be tapped until about the eighth year.

The bulk of the Castilloa rubber obtained in Mexico and Central America at the present time is collected by the natives from wild trees. The method of tapping varies in the different districts; single oblique incisions, V incisions, or spiral incisions extending all round the trunk are used, and sometimes the bark is scored with cuts all over. The native methods of preparing the rubber are frequently very crude, and consequently the product is often of inferior quality.

On the plantations the trees are usually tapped on the half-herring-bone system, and the rubber is prepared either by allowing the diluted latex to "cream" and then submitting the separated rubber globules to pressure, or by treating the latex in a centrifugal machine. The rubber obtained by either of these processes is of very good quality and realises prices almost equal to that of fine hard Para.

The following section gives the results of the examination of Castilloa rubber from India, Zanzibar, the West Indies and Venezuela.

INDIA.

I.—*Castilloa Rubber from Kullar, Nilgiris* (1908).

This sample was labelled as follows:—"No. 2. Castilloa rubber from trees planted in the Government Experimental Garden, Kullar (1,300 feet), Nilgiris, in April, 1902; collected June, 1908." It weighed $6\frac{1}{2}$ oz., and consisted of a rough sheet of dark brown

rubber, containing a fair amount of vegetable impurity. The rubber was rather soft, slightly sticky and weak.

A chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·5	—
Caoutchouc	62·7	63·6
Resin	32·0	32·5
Proteid	0·9	0·9
Insoluble matter ...	2·9	3·0
Ash	2·29	2·4

The rubber was valued at 3*s.* 2*d.* to 3*s.* 4*d.* per lb. in London, with fine hard Para quoted at 5*s.* 1*d.* per lb.

This rubber was of inferior quality, owing to the large percentage of resin present. The trees from which the sample was obtained were, however, only six years old, and it is probable that the quality of the rubber will improve as the trees become older.

II.—*Castilloa Rubber from Burliar, Nilgiris* (1908).

The specimen bore the following label:—"No. 3. Castilloa rubber from the Government Experimental Garden, Burliar (2,400 feet), Nilgiris, February, 1908." It weighed 5¾ oz., and consisted of rough sheets of rubber varying in colour from light to dark brown, and containing traces of vegetable impurity. This rubber was much stronger than the preceding specimen from Kullar. On analysis it gave the following figures:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·2	—
Caoutchouc	86·1	86·2
Resin	12·8	12·9
Proteid	0·5	0·5
Ash	0·4	0·4

The rubber was valued at 3*s.* 6*d.* to 3*s.* 8*d.* per lb. in London, with fine hard Para quoted at 5*s.* 1*d.* per lb.

This sample of Castilloa rubber from Burliar was much superior in composition and physical properties to the specimen from Kullar. No information was furnished regarding the age of the trees from which the rubber was obtained.

ZANZIBAR (1908).

This specimen of Castilloa rubber weighed 1½ oz. and consisted of two flat pieces of rubber which had apparently been cut from a larger lump. The rubber was black and possessed a slight odour; it exhibited fair elasticity and tenacity.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·6	—
Caoutchouc	75·8	77·1
Resin	20·2	20·5
Proteid	1·5	1·5
Insoluble matter ...	0·9	0·9
Ash	0·4	0·4

The sample was too small for trustworthy valuation, but the rubber was of inferior quality on account of the high percentage of resin present. The latter feature suggests that the rubber was derived from young trees.

TRINIDAD AND TOBAGO.

I.—*Two Samples of Castilloa Rubber* (1903).

Two small samples of rubber, prepared respectively from old and young trees of *Castilloa elastica*, were forwarded to the Imperial Institute for comparative chemical examination by the Superintendent of the Royal Botanic Gardens, Trinidad. In the accompanying letter it was stated that the samples had been prepared from the latex by creaming and draining, and that the rubber derived from the young trees was much inferior in physical properties to that yielded by the older trees of the same species.

"No. 1. Rubber from young trees (4 years old)."

The specimen showed very little resemblance to true rubber, and was evidently highly resinous. It was almost black, rather hard in the lump, but could be moulded by pressure, and was easily indented with the finger nail; small fragments were soft and sticky. It exhibited very little tenacity and no elasticity.

"No. 2. Rubber from old trees."

This was a specimen of good rubber, almost black, only slightly sticky, very elastic and exhibiting considerable tenacity.

A chemical examination of each of the two specimens gave the following results:—

——	Moisture.	Caoutchouc.	Resin.	Insoluble matter.	Ash.
Rubber from young trees...	0·6	33·6	64·1	1·7	0·35
Rubber from old trees ...	0·4	81·9	15·8	1·9	0·34

The purified caoutchouc from the rubber of the young trees was very soft and sticky, whereas that furnished by the rubber from the older trees exhibited very satisfactory physical properties.

These analyses amply confirm the opinion based upon the appearance of the samples, and prove that the rubber prepared from the latex of the young trees of *Castilloa elastica* is a very inferior product, consisting largely of resin. The results agree with previous analyses recorded by different investigators, who have invariably found that the amount of resin in the latex of *Castilloa elastica* is very large in the young trees, but gradually diminishes

with age, until after the eighth year or so the tree yields rubber of good quality. Practical experiments in the cultivation of *Castilloa elastica* fully support this conclusion. The age of the "old trees" under notice was not stated, but the amount of resin present in the rubber, viz., 15·8 per cent., is much greater than is permissible in rubber of good quality.

II.—*Five Samples of Castilloa Rubber* (1903).

These samples of Castilloa rubber, prepared by different methods from old and young trees, were forwarded by the Superintendent of the Royal Botanic Gardens for comparative examination.

"No. 1. 350 c.c. Castilloa latex from trees $4\frac{1}{2}$ years old. Added 150 c.c. alcohol. After coagulation and draining the rubber blackened quickly. Obtained 140 grams of wet rubber."

The specimen consisted of a single piece about 4 in. by 2 in. by 1 in. weighing $3\frac{1}{3}$ oz., and was evidently of very inferior quality. The mass was very hard, but could be indented with the finger nail and its shape altered by compression; it was almost black externally, but dark brown within, and small fragments of bark were distributed through it. Small pieces of the material were soft, and exhibited only slight elasticity and very little tenacity.

"No. 2. 350 c.c. of Castilloa latex from trees $4\frac{1}{2}$ years old. Added two litres of water and set to cream for 12 hours. Coagulated with alcohol and obtained 118 grams of wet rubber. This appears brittle. Creamed rubber is always cleaner and whiter than rubber from latex coagulated as gathered. It appears to wash away much proteid matter."

This was very similar to the preceding sample No. 1 in appearance and characters, but was a little softer and more elastic. It was a single piece about 5 in. by 2 in. by 1 in. weighing 3 oz., dark brown externally, but much lighter within, the freshly-cut surface having a glossy appearance.

"No. 3. 500 c.c. Castilloa latex from trees $4\frac{1}{2}$ years old. Poured direct on copper mesh (fine wire) and allowed to drain. Rubber coagulated by air naturally in 48 hours. Was taken off wire and doubled up."

The specimen consisted of a sheet of black rubber, about 12 in. square and $\frac{1}{8}$ in. thick, which was slightly mouldy on the surface. It was of very inferior quality, being only slightly elastic, and exhibiting very little tenacity.

"No. 4. 600 c.c. of Castilloa latex from trees over 12 years old. Added alcohol to coagulate. Coagulation appeared imperfect. To be compared with No. 1—old and young."

This specimen consisted of a single piece of black rubber weighing 7 oz. When cut open it was found to be very porous and to contain a considerable quantity of acid liquid; it was therefore cut into slices and air-dried before analysis. It also contained numerous fragments of bark and wood of rather large size, which, on removal, were found to amount to 4·6 per cent. of the total weight. The rubber was very elastic and tenacious, and only slightly sticky.

"No. 5. Specimen of rubber made from washed and creamed latex of trees 12 years old and over. Coagulated with alcohol. This appears to be the best specimen of Castilloa sent."

The sample was a small piece of black rubber weighing 1 oz.; internally it was a dark greyish colour throughout, dry, and quite free from foreign matter. The physical characters of the rubber were very satisfactory; it exhibited considerable elasticity and tenacity, and was not sticky. In appearance and characters it was certainly the best specimen of the series.

Results of Examination.

The following results were obtained on analysis of the various samples:—

—	Rubber as received.					Composition of dry rubber.				
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Moisture ...	10·3	4·3	8·0	15·2*	2·2	—	—	—	—	—
Caoutchouc...	37·1	41·1	40·8	70·1	89·1	41·3	43·0	44·4	82·7	91·2
Resin	47·1	53·8	45·4	11·7	8·2	52·6	56·2	49·3	13·8	8·3
Insoluble matter.	5·5	0·8	5·8	3·0†	0·5	6·1	0·8	6·3	3·5	0·5
Ash	1·47	0·31	1·24	0·79	0·25	1·64	0·32	1·34	0·93	0·25
Age of trees (years).	4½	4½	4½	Over 12	12 and over.	4½	4½	4½	Over 12	12 and over.

* This specimen was air-dried before analysis.
† Exclusive of 4·6 per cent. of bark removed before analysis.

It will be seen from these figures that the three specimens of Castilloa rubber, Nos. 1, 2 and 3, which were obtained from trees 4½ years old, contain very large amounts of resin, viz., 52·6, 56·2 and 49·3 per cent. respectively in the dry material, and they would, therefore, possess little value as rubbers. The results of the chemical examination confirm the opinion based upon the physical characters of the specimens, and it is clear from these analyses that Castilloa trees 4½ years old will not yield marketable rubber in Trinidad. This conclusion agrees with that arrived at by previous investigators, but it must be remarked that the amount of resin present in the specimens under notice, and also in the small sample of Castilloa rubber from a tree four years old which is dealt with in the preceding report, is considerably greater than has been hitherto recorded for Castilloa rubber obtained from trees of the same age growing in other countries. Thus Weber in some experiments conducted at Las Cascadas on the isthmus of Columbia found that the rubber obtained from the trees of *Castilloa elastica* 4 and 5 years old contained 26·47 and 18·18 per cent. of resin respectively, which is about half the amount found in the present case. The much higher percentages of resin found in the specimens from Trinidad may possibly be due to differences of climate, soil, &c. The different methods of preparation employed in the three cases has not influenced the composition of the rubber to any appreciable extent, the only striking difference being that No. 2, which was prepared by creaming, contained very little insoluble matter and ash as compared with the other two specimens.

The two samples of Castilloa rubber, Nos. 4 and 5, which were obtained from trees 12 years old and upwards, were of much better quality than the preceding specimens, though the amount of resin present, 13·8 and 8·3 per cent., is still higher than is usually found in the best qualities of this variety of rubber. Specimen No. 5 is the best of the series both as regards chemical composition and physical characters.

Commercial Value.

Samples of the two rubbers, Nos. 4 and 5, were submitted for valuation to brokers, who were informed of the results which had been obtained by chemical examination. The brokers valued No. 4 at 2*s*. 4*d*. per lb. and No. 5 at 2*s*. 9*d*. per lb. in London, with fine hard Para quoted at 4*s*. 2*d*. per lb.

III.—*Castilloa Rubber prepared by Weber's Method* (1903).

This sample of rubber of *Castilloa elastica* had been prepared by the Superintendent of the Botanic Gardens according to the method suggested by Dr. C. O. Weber, which consists in the addition of formaldehyde to the creamed latex. The following particulars were supplied regarding the exact procedure adopted:—

"Latex from Castilloa trees 14 to 16 years old, 500 c.c., creamed in four times its volume of clean water, three times in succession to remove albuminoids. Added 20 c.c. of commercial formalin to latex when creamed on last lot of water. No cohesion took place until 96 hours after mixing. Rubber then lifted and pressed. Cold water was used."

The specimen was a semicircular cake, 4 inches in diameter and 1 inch in thickness, which weighed about 2 oz. Externally it was light brown, but within it was quite white, perfectly dry and free from foreign matter. The rubber exhibited very satisfactory physical properties; it was not sticky, and was very elastic and tenacious.

The following results were obtained on chemical examination:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·5	—
Caoutchouc	82·6	91·2
Resin	7·4	8·2
Insoluble matter ...	0·5	0·6
Ash	0·26	0·29

These figures are practically identical with those furnished by sample No. 5 of the preceding report, which was prepared by coagulating the washed and creamed latex with alcohol. The physical characters of the two specimens were also very similar, the only difference being that the sample prepared by Weber's method was much lighter in colour.

The brokers also regarded the two specimens as of equal value, and quoted for each a price of 2*s*. 9*d*. per lb., with fine hard Para at 4*s*. 2*d*. per lb.

IV.—*Twelve Samples of Castilloa Rubber* (1907).

These specimens were forwarded by the Superintendent of the Royal Botanic Gardens in continuation of the previous investigations.

"No. 1. Castilloa rubber. Cake. Washed in three waters, skimmed and allowed to coagulate in glass saucer."

"No. 2. Castilloa rubber. Cake. Latex washed through strainer with 12 volumes of water and left in vessel to coagulate. It was taken as a cake from surface 6 days afterwards and pressed."

"No. 3. Castilloa scrap. Collected from trees which furnished Nos. 1 and 2."

These specimens were prepared from Castilloa trees which were planted to fill up the gaps in a permanent plot of *Hevea brasiliensis*. The trees are 7½ years old, but are of small size owing to the *Hevea* trees outgrowing them.

"Nos. 4 and 5. Castilloa block and scrap from trees 17 years old."

"Nos. 6 and 7. Castilloa sheet and scrap."

"Nos. 8 and 9. ,, ,, ,,"

"No. 10. ,, ,, from trees 6 years old."

"Nos. 11 and 12. ,, ,, and scrap."

Specimens Nos. 1, 2 and 3 were all prepared from trees growing on lands belonging to the Botanical Department, whereas specimens Nos. 4 to 12 represent the rubber produced on private estates in Trinidad, and for which, it is stated, prices of from 3*s*. to 4*s*. 3*d*. per lb. were being obtained.

"No. 1. Castilloa rubber from trees 7½ years planted." Weight 6 oz.

A thick cake of rubber, 5 inches in diameter and from ⅛ to ½ inch thick.

The rubber was almost black externally, but greenish-white within when freshly cut; it was clean, slightly sticky, and exhibited very poor elasticity and tenacity.

The results of the analysis were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·5	—
Caoutchouc	46·4	47·5
Resin	50·6	52·0
Proteid	0·5	0·5
Insoluble matter ...	nil.	nil.
Ash	0·24	0·25

This sample of rubber was of inferior quality on account of the very high percentage of resin present. It was valued at 2*s*. per lb. in London, with fine hard Para at 4*s*. 7*d*. per lb.

"No. 2. Castilloa rubber from trees 7½ years planted." Weight 8½ oz.

A thin cake of rubber, 6 inches in diameter and 1 inch thick. The rubber was almost black externally but lighter within, clean and slightly sticky; its physical properties were not very satis-

factory, although it was superior in this respect to the preceding specimen, No. 1.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·5	—
Caoutchouc	57·6	59·1
Resin	36·0	36·9
Proteid	1·0	1·0
Insoluble matter ...	2·9	3·0
Ash	2·4	2·5

This sample contained less resin than No. 1, but the amount of this constituent was still very much greater than is admissible in rubber of good quality. It was valued at 3*s.* per lb. in London. The scrap rubber, sample No. 3, corresponding to Nos. 1 and 2, was valued at 2*s.* 10*d.* per lb.

"No. 4. Castilloa block from trees 17 years old." Weight 2¼ lb.

An oblong piece of rubber, about 2 feet long, from 3 to 4 inches wide and 1 inch thick.

The rubber was brown externally but lighter within; it was clean, free from stickiness, and exhibited fair elasticity and tenacity.

The following results were obtained on analysis:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	8·0	—
Caoutchouc	69·2	75·2
Resin	21·2	23·0
Proteid	0·6	0·7
Insoluble matter ...	1·0	1·1
Ash	1·99	2·15

This sample of Castilloa rubber was of better quality than Nos. 1 and 2, but the amount of resin was still excessive. It was valued at 3*s.* 6*d.* per lb. in London. The scrap rubber from the same source, sample No. 5, was valued at 2*s.* 1*d.* per lb.

"No. 6. Castilloa sheet." Weight 1 lb.

A large sheet of rubber, 12 by 14 inches, and from $\frac{1}{16}$ to $\frac{1}{8}$ inch thick.

The rubber was clean, pale yellow, and free from stickiness; it was, however, weak and tore readily.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·8	—
Caoutchouc	76·1	76·7
Resin	21·5	21·7
Proteid	0·5	0·5
Insoluble matter ...	1·1	1·1
Ash	0·71	0·72

This sample was very similar in composition to No. 4, but was a little weaker. It was valued at 3*s.* 5*d.* per lb. in London. The corresponding scrap rubber, No. 7, was valued at 3*s.* per lb.

"No. 8. Castilloa sheet." Weight 5½ oz.

Two thin sheets of clean rubber, pale colour, sticky. The rubber was very weak and tore readily.

The following results were obtained on analysis:—

	Per cent.
Moisture	0·1
Caoutchouc	60·9
Resin	37·2
Proteid	0·4
Insoluble matter...	1·4
Ash	0·37

This sample was of inferior quality on account of the high percentage of resin. In composition it agrees well with sample No. 2. The scrap rubber from the same source, No. 9, contained a little less resin than the sheet, viz. 32·4 per cent. The sheet rubber was valued at 2*s.* 3*d.* per lb., and the corresponding scrap rubber in ball form at 3*s.* per lb. in London.

"No. 10. Castilloa sheet." Weight 5 oz.

Three small irregular cakes of clean black rubber, which exhibited fair elasticity and tenacity, but tore when stretched.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·0	—
Caoutchouc	75·4	76·1
Resin	20·4	20·6
Proteid	0·6	0·6
Insoluble matter ...	2·6	2·7
Ash	2·17	2·19

This sample resembled specimens Nos. 4 and 6 in composition and quality. It was valued at 3*s.* 6*d.* per lb. in London.

"No. 11. Castilloa sheet." Weight 15 oz.

Two thin sheets of rubber about 10 inches square. The rubber was clean, well prepared, pale in colour and free from stickiness; it exhibited good elasticity and tenacity, being much superior in these respects to all the other samples.

The results of the analysis were as follows:—

	Per cent.
Moisture	0·1
Caoutchouc	83·0
Resin	15·6
Proteid	0·4
Insoluble matter...	0·9
Ash	0·51

This sample of Castilloa rubber contained less resin than any of the other specimens. It was very well prepared and is certainly the best sample in the series. It was valued at 4*s.* 6*d.* per lb. in

London, the corresponding scrap rubber, No. 12, being valued at 2*s*. 7*d*. per lb.

The two samples of Castilloa rubber, Nos. 1 and 2, from trees growing on land belonging to the Botanical Department, contain exceptionally high percentages of resin (viz., 52 and 37 per cent. respectively) for the product of 7½ year old trees. It may, however, be noted that the trees in question are stated to be of small growth owing to the fact that they were planted along with Para trees and the latter had outgrown them.

The other samples of Castilloa rubber were derived from private estates in Trinidad. Of these No. 8 contained 37·2 per cent. of resin, thus agreeing in composition with No. 2, whereas in the other specimens, Nos. 4, 6, 10 and 11, the amounts of resin were much less, ranging from 15·6 to 23 per cent. Even these latter percentages are much higher than those usually recorded for Castilloa rubber from mature trees.

The valuations of the sheet Castilloa rubbers vary from 2*s*. to 4*s*. 6*d*. per lb. and those of the "scrap" from 2*s*. 1*d*. to 3*s*. per lb., with fine hard Para at 4*s*. 7*d*. per lb. It may be noted that in the case of the specimens Nos. 8 and 9 the scrap rubber in ball form was valued by the brokers at more than the corresponding sheet. The latter was exceptionally weak, whereas the ball of scrap rubber appeared to be much stronger and contained a little less resin.

V.—*Castilloa Rubber from Tobago* (1909).

The specimen was a large square sheet of *Castilloa elastica* rubber about ⅛ inch thick and weighing 2½ lb. The rubber was black, clean, and well prepared; its physical properties were very satisfactory.

It had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·0	—
Caoutchouc	91·1	92·0
Resin	6·1	6·2
Proteid	0·8	0·8
Insoluble matter	1·0	1·0
Ash	2·20	2·22

The sample was valued at 4*s*. 4*d*. per lb. in London, with fine hard Para from South America quoted at 5*s*. per lb. This rubber is of good quality, and would be readily saleable.

VI.—*Castilloa Rubbers from Tobago* (1909).

These specimens of Castilloa rubber were stated to have been prepared by a new centrifugal process.

Description and Results of Examination.

A. The first specimen received bore the following label: "Department of Agriculture. Castilloa rubber prepared by a new process. From Tobago. 26/6/09." Weight, 1½ oz.

It consisted of a square sheet of very pale rubber, clean and

excellently prepared. The rubber was rather weak and much inferior in physical properties to good Para.

The results of the chemical examination were as follows:—

	Per cent.
Moisture	0·1
Caoutchouc	70·7
Resin	28·6
Proteid	0·5
Ash	0·1

The analysis shows that the rubber contains a high percentage of resin, which adversely affects its physical properties. The percentages of moisture, proteid and ash are extremely low, and it is evident that the rubber has been very well prepared.

No information was furnished as to the age of the trees from which the rubber was obtained.

Four other specimens of Castilloa rubber prepared by this centrifugal method were subsequently received.

"No. 1. Not creamed. Spun within an hour of tapping. Trees, 7-8 years old." Weight, ¾ oz.

A thin sheet of pale brown rubber, clean and well-prepared. The rubber was stronger than the previous specimen A, but still a little weak. The sample was too small for analysis.

"No. 2. Creamed, spun same day. Trees, 7-8 years old." Weight, ⅔ oz.

Very similar to sample A in appearance and physical properties. The sample was too small for analysis.

"No. 3. Creamed, spun next day. Trees, 7-8 years old." Weight, ⅔ oz.

A thin sheet of brown rubber, rather soft and weak. The specimen was insufficient for chemical examination.

"No. 4. Creamed and washed over and over again, spun next day. Trees, 7-8 years old." With this specimen is included another which was labelled as follows: "Same as No. 4, but deposited on brass plate fitted inside bowl."

These two specimens had become firmly adherent, and could not be separated from one another. They were exactly similar in appearance and were treated together. The united sample weighed 1⅓ oz.

The rubber was pale, slightly sticky, soft and weak. In physical properties, it was the worst of the series.

A chemical examination showed that the rubber contained 0·04 per cent. of moisture and 34·2 per cent. of resin. The quantity of material was not sufficient for complete analysis.

Commercial Value.

The specimens, with the exception of No. 4, were valued as follows:—

		Per lb. s. d.
A.	Fine thin sheet	6 10
No. 1.	Fine thin brown sheet ...	6 10
,, 2.	ditto. ...	6 11
,, 3.	Thin sheet of rather soft character	6 4

Specimen No. 4 was of very inferior quality on account of its soft and resinous character, and would realise a much lower price than those quoted for the other specimens.

On the date of the above valuations, fine hard Para was quoted at 8*s*. 10*d*. per lb. in London.

Conclusions.

Three of these specimens of Castilloa rubber, viz., Nos. 1, 2 and A, are of excellent quality, and it is clear that the centrifugal method adopted for their preparation is capable of yielding very good results. Unfortunately, the latex used for the experiments, judging by the composition of sample A, was very resinous, so that the resulting rubber is inclined to be soft and weak.

It is not possible from the examination of such small specimens to express any definite opinion regarding the best method of preparation. Sample No. 1, "Not creamed. Spun within an hour of tapping," was a little stronger than specimens No. 2, "Creamed, spun same day," and sample A, both of which, however, were slightly superior to it in colour. No. 3, "Creamed, spun next day," was darker and much weaker than the preceding three specimens; while No. 4, "Creamed and washed over and over again, spun next day," was the worst specimen of the series as regards physical properties.

It would, therefore, appear that the specimens prepared from the latex on the day of collection are much superior to those in which the latex was kept until the next day. Further experiments will be necessary to determine whether it is advantageous to cream the latex before spinning. The creamed sample No. 2 is superior in colour to No. 1, which was not creamed, and on that account was valued at 1*d*. per lb. more, but the rubber was not quite so strong as No. 1. Unfortunately, the specimens Nos. 1 and 2 were too small for analysis, so that it was not possible to determine the composition of the "creamed" and "uncreamed" rubber for comparison. Larger samples (about ½ lb. each) of rubber prepared by these methods should be submitted for this purpose.

In view of the successful results obtained by this method of preparation, it would be of considerable interest if further experiments could be conducted on the same lines with latex derived from older trees, as such latex would probably be less resinous and would therefore yield a better product.

DOMINICA (1909).

The specimen, which was labelled "Large biscuit of *Castilloa elastica*," weighed 1 lb. 2 oz. It consisted of a large rough biscuit of black rubber, about 11 inches in diameter and ⅜ inch thick. The rubber was clean, dry and well prepared; its physical properties were very satisfactory.

The results of the analysis were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·9	—
Caoutchouc	84·0	85·6
Resin	9·2	9·4
Proteid	3·7	3·8
Insoluble matter ...	1·2	1·2
Ash	2·09	2·13

The sample was valued at about 3*s*. 6*d*. per lb. in London, with fine hard Para from South America quoted at 4*s*. 3½*d*. per lb.

The results of the analysis show that this rubber is of good quality, though the percentages of resin and proteid are a little high.

St. Lucia (1909).

This sample, which was labelled "Small slab of biscuit rubber, *Castilloa elastica*," weighed 3 oz. It consisted of a small cake of rubber about 6 inches long, 3 to 4 inches wide and ¼ inch thick. The rubber was almost black, but was clean and well prepared; its physical properties were very satisfactory.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·3	—
Caoutchouc	88·6	88·9
Resin	9·1	9·1
Proteid	1·3	1·3
Insoluble matter ...	0·7	0·7
Ash	0·46	0·46

The sample was valued at about 3*s*. 6*d*. per lb. in London, with fine hard Para from South America quoted at 4*s*. 3½*d*. per lb.

The analytical results show that this Castilloa rubber from St. Lucia is of good quality, although the percentage of resin is a little high. This slight defect may possibly disappear as the trees become older. Consignments of similar character to the present sample would be readily saleable.

Venezuela (1905).

A small sample of rubber supposed to have been prepared from Castilloa trees in Venezuela was forwarded to the Imperial Institute by the Superintendent of the Botanical Department in Trinidad.

The sample was labelled "Caoutchouc Castillioa preparado por Prof. Julio Roversi, Caracas," and consisted of a strip of rubber which was light in colour, being almost white internally, and was practically free from foreign matter; it was not sticky and its physical properties were exceedingly good.

The analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·8	—
Caoutchouc	92·8	95·5
Resin	3·7	3·8
Insoluble matter ...	0·7	0·7
Ash	0·4	0·4

It is evident from these figures that the rubber is of very good quality, containing less than 4 per cent. of resin in the dry material. This percentage of resin is very much lower than that found in any of the specimens of rubber from Castilloa trees growing in Trinidad, which have been examined at the Imperial Institute.

The sample was too small to submit for commercial valuation, but there is no doubt that rubber of the same quality would always command a good price in the market.

FUNTUMIA RUBBER.

Funtumia elastica, Stapf.

This tree, known as the West African rubber tree or the Lagos silk rubber tree, belongs to the natural order Apocynaceæ and is a native of tropical Africa. It occurs from Sierra Leone in the west to Uganda in the east, and extends southward into the Congo State. It is a large tree which attains a height of 100 feet, and has a straight cylindrical trunk.

The rubber of *Funtumia elastica* is of very good quality if carefully prepared, but the product obtained by the natives in West Africa is depreciated in value by the crude methods of collection and preparation which they adopt.

In tapping the trees the natives employ the double herringbone system, and the incisions are frequently made to a height of 50 feet or more. The latex is collected at the foot of the tree, and is usually poured, without being strained, into shallow pits dug in the ground, where it is allowed to remain until coagulation has taken place and the rubber is sufficiently firm to be handled. The product thus obtained is a porous mass of rubber containing a large quantity of the serum of the latex, and consequently very liable to ferment and develop objectionable odours. The rubber prepared in this way is known on the market as "Lump." The value of the rubber is often still further depreciated by the native practice of adding to the latex of *Funtumia elastica* before coagulation the latices of various non-rubber yielding plants, which render the rubber resinous and adversely affect its physical properties.

Attempts are now being made to induce the natives to keep the latex of *Funtumia elastica* pure, and to prepare the rubber either by boiling the diluted latex or by the addition to the latex of a hot infusion of Bauhinia leaves. The freshly coagulated rubber is then rolled out into "biscuits." A considerable number of specimens of Funtumia rubber prepared by these methods have been examined at the Imperial Institute.

Large numbers of the Funtumia trees in West Africa have been destroyed by the excessive tapping to which they have been subjected by the natives. Efforts are, however, being made to remedy this by inducing the natives to form plantations of the trees, and by instructing them in rational methods of collecting and preparing the rubber. Large numbers of Funtumia trees have been planted in the Gold Coast and Southern Nigeria by the Governments, by European planters and by the natives, and some of these plantations have now reached the production stage.

In 1903 the occurrence of *Funtumia elastica* in Uganda was recorded; the tree was first discovered in the Mabira Forest, and has since been found to be distributed through the other forests of the Protectorate. Consignments of Funtumia rubber prepared by modern methods in Uganda have realised very high prices in the London market.

The following section includes analyses of Funtumia rubber from Sierra Leone, the Gold Coast, Northern and Southern Nigeria, Liberia, Uganda and Trinidad.

SIERRA LEONE.

I.—*Gbogboi Rubber from the Panguma District* (1906).

This rubber is derived from a tree bearing the same name, and the specimens of the leaves which accompanied the sample were identified at Kew as belonging in all probability to *Funtumia elastica*, Stapf, the West African rubber tree.

This identification has since been confirmed, and the existence in Sierra Leone of this important rubber-yielding tree is now fully established.

The sample of rubber was a large, dark-coloured ball which weighed about 16 oz. It was slightly sticky and contained a considerable amount of vegetable impurity, but exhibited good elasticity and tenacity.

On examination it was found to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·1	—
Caoutchouc	80·3	82·0
Resin	4·3	4·4
Proteid	2·5	2·5
Insoluble matter ...	10·8	11·1
Ash	2·35	2·40

These results show that so far as chemical composition is concerned the rubber would be satisfactory if it were not for the large amount of vegetable impurity present. The percentages of resin and proteid are low, and there is no doubt that, if carefully collected and prepared, this rubber would be of very good quality. The present sample is rather unsatisfactory in physical characters owing to its stickiness, which has probably been caused by over-heating.

The sample was submitted for commercial valuation to brokers, who stated that it would be worth about 2*s.* 3*d.* per lb. in London, with fine hard Para quoted at 5*s.* 5½*d.* per lb. There is little doubt, however, that a carefully prepared sample free from stickiness would fetch a much higher price.

II.—"Funtumia elastica *rubber. No water added to latex.*" (1908)

The sample consisted of three thin sheets of rubber and one small thicker piece, all of which had a rather rough appearance. The rubber was brown, clean, free from stickiness and had apparently been smoked; its physical properties were very satisfactory.

An analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·5	—
Caoutchouc	83·5	86·6
Resin	5·7	5·9
Proteid	5·8	6·0
Insoluble matter ...	1·5	1·5
Ash	1·17	1·20

The specimen was valued at about 3*s*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

The rubber is of good quality, but the rough appearance and dark colour of the biscuits detract slightly from the market value.

III.—"*Funtumia Rubber. Prepared by diluting 1 part of the Latex with 10 parts of Water and Boiling.*" (1907)

The specimen consisted of nine irregular flat biscuits which were very moist when received, and had consequently to be partially dried before analysis and valuation. The biscuits were dark-coloured, clean, rather rough on the surface and free from stickiness. The physical properties of the rubber were very satisfactory.

An analysis gave the following results:—

	Rubber after partial drying. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·4	—
Caoutchouc	81·9	90·5
Resin	5·7	6·3
Proteid	1·8	1·9
Insoluble matter ...	1·2	1·3
Ash	0·27	0·29

The rubber was described by brokers as "fairly clean rough biscuits; strong, well-prepared and in good condition," and was valued at 4*s*. to 4*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

This rubber is of good quality, containing over 90 per cent. of caoutchouc in the dry material, whilst the amounts of resin, proteid and insoluble matter are all low. The sample as received contained an excessive quantity of moisture, and in consequence there had been a considerable development of mould on the surface of the biscuits during transit. It was stated, however, that the sample had not been dried thoroughly before despatch as would be done in the case of rubber prepared for sale. The price quoted for the biscuits after partial drying here was very satisfactory.

This method of preparing Funtumia rubber, if carefully conducted, will furnish a product of much better quality than that obtained by the spontaneous coagulation of the latex in shallow vessels. The diluted latex should be strained before coagulation is induced, and great care should be taken that the rubber is not overheated, as it is thereby rendered sticky and of inferior value.

IV.—"*Funtumia Rubber. Prepared by diluting the Latex with an equal quantity of Water and Boiling.*" (1907)

Two small oval pieces of almost black rubber, slightly mouldy on the surface, clean and free from stickiness. The rubber exhibited very good elasticity and tenacity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	7·9	—
Caoutchouc	84·0	91·2
Resin	5·3	5·7
Proteid	2·4	2·6
Insoluble matter ...	0·4	0·4
Ash	0·30	0·42

The sample was valued at 4*s*. per lb. in London, with fine hard Para at 4*s*. 7*d*. per lb.

This rubber agrees well in composition with the preceding specimen and is of good quality.

Gold Coast.

I.—*Ofruntum Rubber* (Funtumia elastica) *from Aburi* (1906).

Two samples of this rubber were submitted for examination.

"Sample No. XI. Collected near Aburi. Latex coagulated by exposure to atmosphere."—This weighed 5 oz. and consisted of a single thick biscuit of rubber, which was almost black externally but showed a few white patches internally when freshly cut. The rubber exhibited very good elasticity and tenacity.

"Sample No. XII. Collected near Aburi. Latex coagulated by boiling."—It weighed 4½ oz. and consisted of a single sheet of rubber, brownish-black externally but whitish within when freshly cut. The rubber exhibited very good elasticity and tenacity, but was not quite equal in appearance to No. XI.

The chemical examination gave the following results, and for comparison of the two samples the figures representing the composition of the dry rubber have been added:—

—	Rubber as received.		Composition of dry rubber	
	No. XI.	No. XII.	No. XI.	No. XII.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	7·9	6·3	—	—
Caoutchouc	78·0	81·5	84·6	86·9
Resin	5·3	8·5	5·8	9·1
Proteid	7·6	3·2	8·3	3·4
Ash	1·2	0·5	1·3	0·6

It will be observed from a comparison of these figures that the two samples of Funtumia rubber vary considerably in the proportions of certain constituents, although the percentages of caoutchouc in the dry materials are approximately the same. Sample No. XII. contains much more resin than No. XI., but on the other hand the amounts of proteid and ash in No. XII. are

less than half the quantities found in No. XI. The difference in the method of preparation is no doubt responsible for the higher percentages of proteid and ash present in No. XI.

The two samples of rubber were submitted to brokers for valuation. No. XI. was described as clean black sheet, well prepared, and was valued at 5*s*. 3*d*. per lb. in London. No. XII. was stated to be slightly inferior to the preceding sample, and was valued at 4*s*. 6*d*. per lb. The current value of fine hard Para was 5*s*. 4*d*. per lb.

II.—*Biscuits of Funtumia Rubber* (1907).

These specimens of Funtumia rubber had been prepared experimentally in biscuit form by allowing the latex to stand in shallow vessels until coagulation occurred. A little formalin was added to the latex in each case.

Nos. 1 and 2. Thin circular sheets of rubber, light brown, clean but rather sticky. The rubber was very deficient in elasticity and tenacity.

An analysis of No. 1 gave the following results:—

	Per cent.
Moisture	4·2
Caoutchouc	55·3
Resin	27·5
Proteid	9·8
Insoluble matter	3·2
Ash	1·73

These samples were not submitted for commercial valuation, as they are of inferior quality and do not represent the rubber usually obtained from *Funtumia elastica*.

The analysis shows that the rubber is of very resinous character, and consequently unsatisfactory in physical properties. The amount of resin is very much higher than has been found in any specimen of *Funtumia elastica* rubber examined at the Imperial Institute, and there is little doubt that an inferior latex from some other plant was included with the product during collection.

Nos. 3-8. These specimens were very similar in appearance, consisting of circular cakes of dark-brown rubber, about 6 inches in diameter and ⅜ inch thick. The rubber was well prepared and exhibited good elasticity and tenacity.

An analysis of No. 5 gave the following results:—

	Per cent.
Moisture	3·6
Caoutchouc	70·0
Resin	9·5
Proteid	10·2
Insoluble matter	6·7
Ash	1·11

The rubber was valued at 4*s*. 6*d*. to 4*s*. 9*d*. in London, with fine hard Para quoted at 5*s*. 2*d*. per lb.

This rubber is of good quality, although the percentages of resin and proteid are higher than is desirable. Consignments of similar quality would be readily saleable at satisfactory prices.

No. 9. A thin circular cake of rubber, about 7 inches in diameter and ⅛ inch thick, which was almost black and had a rough surface. The rubber exhibited good physical properties.

An analysis furnished the following results:—

	Per cent.
Moisture	4·7
Caoutchouc	72·7
Resin	9·2
Proteid	10·2
Insoluble matter	3·2
Ash	1·10

The specimen was valued at 3*s.* 9*d.* to 4*s.* per lb. in London, with fine hard Para quoted at 5*s.* 2*d.* per lb.

The rubber is very similar in composition to No. 5, but had not such a good appearance.

Nos. 10-19. These specimens were very similar in appearance, and consisted of circular cakes of dark-brown rubber, about 6 inches in diameter and ¼ inch thick. The rubber was well prepared, very clean, and its physical properties were very satisfactory.

An analysis of No. 13 gave the following results:—

	Per cent.
Moisture	3·1
Caoutchouc	80·2
Resin	8·0
Proteid	7·8
Ash	0·9

The rubber was valued at 4*s.* 8*d.* to 4*s.* 9*d.* per lb. in London, with fine hard Para quoted at 5*s.* 2*d.* per lb.

Sample No. 13 is the best of the specimens analysed, the percentages of resin and proteid being lower and the rubber free from insoluble impurities.

Nos. 20 and 21. These two samples were large thick sheets of black rubber, about 11 inches square and from ¼ to ⅜ inch thick. The rubber was clean and strong.

An analysis of No. 20 gave the following results:—

	Per cent.
Moisture	3·7
Caoutchouc	79·2
Resin	7·2
Proteid	9·6
Insoluble matter	0·3
Ash	1·69

The rubber was valued at 4*s.* 6*d.* per lb. in London, with fine hard Para quoted at 5*s.* 2*d.* per lb.

This rubber is of good quality and is very similar to No. 13 in composition.

Conclusions.

With the exception of Nos. 1 and 2, these samples of Funtumia rubber are of very promising quality, and the valuations obtained show that if prepared in biscuit form the product will fetch a much higher price than the ordinary native lump rubber. It is, however, essential that care should be exercised in the collection of the rubber to avoid the inclusion of inferior latices with that of *Funtumia elastica.* The unsatisfactory character of Nos. 1 and 2 was probably due to an admixture with a resinous latex derived from some other plant.

III.—*Four Specimens of Funtumia Rubber prepared by Different Methods* (1907).

No. 1. "Sample of rubber prepared from *Funtumia elastica* by natural coagulation." Weight, 2·6 oz.

A thin biscuit of black rubber, clean and well prepared. The rubber was free from stickiness and exhibited very good elasticity and tenacity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·5	—
Caoutchouc	80·7	83·6
Resin	6·7	7·0
Proteid	8·7	9·0
Insoluble matter ...	0·4	0·4
Ash	1·53	1·59

The specimen was valued at 4*s*. 3*d*. to 4*s*. 6*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

This rubber is of good quality and consignments of similar character would command a ready sale at satisfactory prices. The percentage of proteid is rather high, as is often the case in Funtumia rubber which has been prepared by spontaneous coagulation.

No. 2. "Sample of rubber prepared from *Funtumia elastica* by a patent coagulating salt." Weight, 1·8 oz.

A thin amber biscuit, opaque in the centre, where the surface was dull and marked by yellowish patches, and translucent at the edges. The rubber was clean, slightly sticky, strong and elastic.

It had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·4	—
Caoutchouc	78·9	81·8
Resin	7·5	7·7
Proteid	8·6	8·9
Insoluble matter ...	1·6	1·6
Ash	1·69	1·74

The specimen was valued at 4*s*. 6*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

The remarks made on the preceding sample No. 1 apply equally to this specimen. The slightly higher price quoted for No. 2 is due to its lighter colour.

No. 3. "Sample of rubber prepared from *Funtumia elastica* by adding an infusion made with the leaves of *Bauhinia reticulata* and drying at a temperature of 190° F."

A thin sheet of brown rubber, clean and well prepared, rather rough surface and exhibiting a slight stickiness. The physical properties of the sample were quite satisfactory.

An analysis gave the following results:—

	Rubber as received. Per cent.
Moisture	0·6
Caoutchouc	88·3
Resin	8·6
Proteid	2·3
Insoluble matter	0·2
Ash	0·52

The sample was valued at 4*s*. to 4*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

This sample of Funtumia rubber is superior in chemical composition to specimens Nos. 1 and 2 on account of the much lower percentage of proteid which it contains. The percentage of resin, however, is a little higher. The lower price quoted for the sample is no doubt due to its appearance, which is not so good as that of the preceding specimens.

No. 4. "Sample of rubber prepared from latex of *Funtumia elastica* by adding an infusion of the leaves of *Bauhinia reticulata*, but dried naturally."

A thin sheet of brown rubber closely resembling No. 3 in all respects.

The rubber had the following composition:—

	Rubber as received. Per cent.
Moisture	0·6
Caoutchouc	89·2
Resin	8·1
Proteid	1·9
Insoluble matter	0·2
Ash	0·37

The specimen was valued at 4*s*. to 4*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

The remarks on sample No. 3 apply equally well to this specimen.

Conclusions.

These four samples of Funtumia rubber are all of good quality, and it will be seen from the valuations obtained that consign-

ments of similar character would realise satisfactory prices. The two specimens coagulated by means of an infusion of the leaves of *Bauhinia reticulata* were not quite equal in appearance to the other two samples, and the price quoted for them is consequently a little lower. They are, however, superior in chemical composition, as they contain much lower percentages of proteid and the amounts of resin are only very slightly higher. The diminution in the amount of proteid is probably due to the fact that when coagulation is brought about by the use of an infusion of Bauhinia leaves the rubber separates from a much larger volume of liquid than in the other cases, with the result that the bulk of the proteid remains in solution.

Experiments conducted at the Imperial Institute with the Bauhinia leaves which accompanied the rubber specimens, show that a hot infusion of the leaves rapidly and completely coagulates the latex of *Funtumia elastica*. The infusion is acid and contains tannin, of which 8 per cent. is present in the dry leaves. It seems probable that the tannin is the active coagulating agent, as it has been found that solutions of gallo-tannic acid and of astringent materials such as the pods of *Acacia arabica* exert a similar action. In places where Bauhinia leaves are not readily available, it will therefore be possible to use some other astringent product for the same purpose.

This method of preparing Funtumia rubber appears to promise very satisfactory results, as it entirely obviates the necessity of applying heat directly to the latex.

IV.—Funtumia elastica *Rubber coagulated with Infusion of* Bauhinia reticulata *leaves* (1908).

A large sheet of rubber from ½ to ¾ inch in thickness, almost black externally but white and moist within when freshly cut, clean and free from stickiness. The rubber exhibited very good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	6·0	—
Caoutchouc	83·1	88·5
Resin	8·4	8·9
Proteid	2·0	2·1
Insoluble matter ...	0·5	0·5
Ash	0·35	0·37

The rubber was valued at 2*s*. 8*d*. to 2*s*. 10*d*. per lb. in London, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This sample of *Funtumia elastica* rubber is of good quality, and very similar in composition to the preceding specimens prepared by the same process. The thickness of the sheet could be reduced with advantage in order to facilitate the complete drying of the rubber before export.

V.—*Four Specimens of Funtumia Rubber prepared experimentally by Different Methods* (1908).

"No. 1." Weight, 11 oz.

A long strip of rubber, about 2½ inches wide and up to ¾ inch thick; almost black externally, but white and moist within when freshly cut. The rubber was very sticky in places, and was rather weak.

It had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·3	—
Caoutchouc	80·2	88·4
Resin	6·6	7·3
Proteid	3·5	3·9
Ash	0·4	0·4

On account of its sticky character this sample was not suitable for commercial valuation.

"No. 2. Rubber latex mixed with four times its volume of water and allowed to stand until it creams. First straining." Weight, 4¼ lb.

A large oval cake of rubber about 1 inch thick, dark-reddish brown externally, very porous and moist within. The rubber was slightly sticky in places, but this appeared to be due to contact with sample No. 1; it exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	13·0	—
Caoutchouc	77·3	88·8
Resin	7·6	8·7
Proteid	1·9	2·3
Ash	0·2	0·2

The rubber was valued at 2*s*. 7*d*. to 2*s*. 8*d*. per lb. in this country, with fine hard Para quoted at 4*s*. 6*d*. per lb.

"No. 3. Rubber latex mixed with four times its volume of water and allowed to stand until it creams. Second straining. A little formalin was added." Weight, 17 oz.

An oval cake of rubber about 1 inch thick, very similar in appearance to No. 2, but not so porous and free from stickiness. The rubber exhibited very satisfactory physical properties.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	11·0	—
Caoutchouc	78·4	88·1
Resin	7·2	8·1
Proteid	3·0	3·4
Ash	0·4	0·4

The rubber was valued at 2*s*. 9*d*. to 2*s*. 10*d*. per lb. in this country, with fine hard Para quoted at 4*s*. 6*d*. per lb.

"No. 4." Weight, 2½ lb.

Seventeen biscuits of dark brown rubber, some of which were very sticky on the surface. The best specimens were of good quality, the rubber being clean, dry and strong, but some of the sticky biscuits were inclined to be weak.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·0	—
Caoutchouc	69·5	71·5
Resin	10·9	11·2
Proteid	10·2	10·5
Insoluble matter ...	6·4	6·7
Ash	0·18	0·2

The best biscuits were valued at 3*s*. 6*d*. to 3*s*. 8*d*. per lb., with fine hard Para at 4*s*. 6*d*. per lb.

The three specimens of Funtumia rubber, Nos. 1, 2 and 3, were prepared in accordance with suggestions made by the Imperial Institute as the result of an examination of *Funtumia elastica* latex. The fresh latex was diluted with 4 or 5 times its volume of water and strained to remove impurities. It was then allowed to stand until the latex "creamed" and a cake of rubber was obtained floating on the surface of the liquid. The cake was removed, pressed, washed and dried.

It was found that the formation of a cake of rubber took from four to five days, and that it was consequently advantageous to add a little formalin to the diluted latex in order to prevent fermentation during the process. Sample 1, which was prepared without such addition, became sticky before it could be removed from the liquid.

These three specimens of rubber agree closely in chemical composition, the dry material containing from 88·5 to 89·0 per cent. of true caoutchouc, 7·3 to 8·7 per cent. of resin, 2·3 to 3·9 per cent. of proteid, and no insoluble matter. These figures are very satisfactory, and show that the samples are of very good quality.

Sample No. 4, which consisted of biscuits prepared by the spontaneous coagulation of the latex, was much inferior in composition to the preceding specimens. It contained much less caoutchouc, more resin and proteid, and also 6·7 per cent. of insoluble matter.

Sample No. 1, as already mentioned, was sticky and unsuitable for commercial valuation, whilst the value of Nos. 2 and 3 was considerably depreciated owing to the fact that the cakes had been made too thick and contained a considerable amount of moisture. On this account the price quoted for them was lower than for the biscuits (No. 4), which, although less satisfactory in chemical composition, were in much better condition. This defect in samples 2 and 3 could be easily remedied, since with a little experience it would be easy to gauge the amount of

diluted latex required to furnish a thin biscuit of rubber which could be quickly dried.

It is evident that this method of preparing Funtumia rubber by allowing the diluted latex to stand until coagulation takes place will give very satisfactory results, but the time taken by the fresh latex to coagulate is probably too long to render the process suitable for the preparation of the rubber on a commercial scale.

VI.—*Funtumia Rubber prepared by means of the Juice of the "Diecha" Vine,* Strophanthus Preussii (1909).

No. 1. Crêpe Funtumia rubber.

This specimen of Funtumia rubber was coagulated by means of "Diecha" juice, and was then crêped in a washing machine. It weighed 10 oz., and consisted of a long ribbon of crêpe rubber from 3 to 5 inches in width. The rubber was light brown, and exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·1	—
Caoutchouc	82·3	83·2
Resin	10·1	10·2
Proteid	3·4	3·4
Insoluble matter ...	3·1	3·2
Ash	0·6	0·6

The rubber was valued at 5*s*. per lb. in London, with fine hard Para quoted at 5*s*. 4*d*. per lb.

This rubber is of very fair quality, though the percentages of resin and insoluble matter are higher than in some samples of Funtumia rubber from the Gold Coast which have been examined at the Imperial Institute. The valuation obtained for the sample is very satisfactory, and a comparison with that for the lump rubber, dealt with in the following report, shows that the commercial value of this Funtumia rubber has been considerably enhanced by its conversion into crêpe.

No. 2. Lump Funtumia rubber.

This specimen of Lump Funtumia rubber was prepared with "Diecha" juice. It weighed 3 lb. 11 oz., and consisted of two large cakes of rubber, reddish-brown externally but almost white within when freshly cut. The rubber was very porous, and contained a large quantity (about 50 per cent.) of an aqueous milky liquid, which held a considerable amount of tannin in solution. The rubber exhibited good elasticity and tenacity.

The chemical examination gave the following results:—

	Composition of partially dried rubber. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·4	—
Caoutchouc	75·8	78·5
Resin	10·0	10·4
Proteid	6·8	7·0
Insoluble matter ...	4·0	4·1
Ash	1·0	1·0

The rubber was valued at 2*s*. 3*d*. per lb. in London, with fine hard Para quoted at 5*s*. 4*d*. per lb.

This specimen contained an excessive amount of moisture; the cakes had been made much too thick and the liquid had not been pressed out. A much larger percentage of proteid was present than in the crêped rubber.

No. 3. "Diecha" Juice.

A small quantity of the "Diecha" Juice used in these experiments was also forwarded for examination. It was labelled "Juice from the Diecha vine used to coagulate Funtumia latex, A.E.E."

A preliminary examination showed that the liquid contained tannin, and it is possible that its coagulating action, like that of an infusion of Bauhinia leaves, may be due to this constituent.

VII.—*Funtumia Rubber prepared by Boiling* (1910).

No. 1. This sample was the portion of rubber which coagulated first on boiling the diluted latex. The sample weighed $1\frac{1}{4}$ lb. and consisted of nine biscuits of light-brown rubber marked by dark patches. The rubber was clean and very well prepared; it exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·8	—
Caoutchouc	89·8	90·5
Resin	7·0	7·1
Proteid	2·0	2·0
Ash	0·4	0·4

The biscuits were valued at 6*s*. to 6*s*. 6*d*. per lb. in this country, with fine hard Para quoted at 7*s*. 7*d*. per lb. and Ashanti Lump at 1*s*. 11*d*. to 2*s*. 3*d*. per lb.

This rubber is of very good quality, the dry material containing over 90 per cent. of caoutchouc, whilst the amounts of resin and proteid are satisfactorily low. The value of the rubber would be enhanced if the formation of the dark patches on the biscuits could be avoided. This discolouration has probably developed during drying, and might be prevented by drying the biscuits more quickly.

It is evident that Funtumia rubber prepared by this method will command prices greatly in excess of those realised by Gold Coast Lump. The use of the process by the natives should therefore be encouraged. Care must, however, be taken that the coagulated rubber is not over-heated, as it thereby becomes sticky and depreciated in value.

No. 2. This sample was the portion of rubber which coagulated last on boiling the diluted latex. It weighed only $1\frac{1}{2}$ oz. and consisted of nine thin sheets of light-brown rubber, very similar in all respects to the preceding specimen No. 1.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·5	—
Caoutchouc	88·0	88·5
Resin	9·2	9·2
Proteid	2·0	2·0
Ash	0·3	0·3

The sample was too small for separate valuation, but it would probably be worth about the same price as No. 1.

This rubber contained 2 per cent. less caoutchouc and 2 per cent. more resin than No. 1, so that it was not quite so satisfactory in composition as the latter.

SOUTHERN NIGERIA.

I.—Funtumia elastica *Rubber from Benin City* (1906).

The sample, which weighed 1 lb. 6 oz., consisted of small, irregular pieces of rubber, which were dark coloured throughout and in some cases slightly mouldy on the surface. A few of the pieces were wet and exhibited a slight stickiness in places. The rubber possessed good elasticity and tenacity, but contained a fair amount of vegetable impurity.

It was stated that the rubber had been prepared by heating the latex.

A chemical examination furnished the following results:—

	Per cent.
Moisture	2·6
Caoutchouc	75·7
Resin	6·4
Proteid	6·3
Insoluble matter	9·0
Ash	1·88

The results of the analysis show that the rubber is of very fair quality, but the amount of insoluble impurity, consisting principally of vegetable matter, is excessive. This defect could be remedied by straining the latex before coagulation.

The rubber was valued by brokers at 3*s*. 9*d*. per lb. in London, with fine hard Para quoted at 5*s*. 4*d*. per lb. The value of the rubber would be enhanced if it were prepared in biscuit form.

II.—*Two specimens of Funtumia Rubber, labelled A and B* (1907).

Sample A was stated to have been prepared by the process of sun drying on a tray, whereas sample B was "cooked in a bottle."

The samples were too small for chemical examination.

Sample A consisted of a portion of a flat cake of rubber about $\frac{3}{8}$ inch in thickness. It was almost black, free from vegetable impurity, dry, and well prepared. The rubber exhibited very good physical properties. It was valued at 4*s*. 6*d*. to 4*s*. 8*d*.

per lb. in London, the current price of fine hard Para from South America being 5s. 2d. per lb.

Sample B was part of a flat cake of rubber and varied from ½ to ⅝ inch in thickness.

It was very similar to the previous specimen, but a little lighter in colour and rather softer. It was valued at 4s. 3d. to 4s. 4d. per lb. in London.

These samples of rubber are of good quality, and consignments of similar character would be readily saleable at satisfactory prices.

III.—*Three specimens of* Funtumia elastica *Rubber, prepared in Biscuit Form* (1908).

These specimens were forwarded by the Provincial Forest Officer at Benin City for comparative examination.

"A. Biscuit rubber made from *F. elastica*, under supervision of A. H. Unwin, Provincial Forest Officer, Benin City." Weight, 1 lb.

The specimen consisted of rough sheets of rubber, varying in colour from light to dark brown, clean, and well prepared. The rubber exhibited good elasticity and tenacity.

An analysis of the rubber showed it to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·6	—
Caoutchouc	87·9	89·4
Resin	8·5	8·6
Proteid	1·6	1·6
Ash	0·4	0·4

The rubber was valued at 3s. 2d. to 3s. 4d. per lb. in this country, with fine hard Para rubber at 4s. 6d. per lb., and Benin lump rubber at 2s. to 2s. 1d. per lb. on the same date.

"B. Biscuit rubber made from *F. elastica*, by Igodaro, Deputy Forest Ranger, Benin City." Weight, 1 lb.

Sheets of rubber similar to sample A, but rougher and darker in colour.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	7·1	—
Caoutchouc	81·6	87·9
Resin	8·3	8·9
Proteid	2·3	2·4
Insoluble matter ...	0·7	0·8
Ash	0·40	0·43

The specimen was valued at 3s. to 3s. 2d. per lb. in this country, with fine hard Para at 4s. 6d. per lb., and Benin lump rubber at 2s. to 2s. 1d. per lb.

"C. Biscuit rubber made from *F. elastica* by the natives, and sold by them to the Factory, Benin City." Weight, 1½ lb.

Coarse sheet rubber, of uneven thickness, dark colour, and not thoroughly dried. The rubber was a little weaker than the other samples.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	8·4	—
Caoutchouc	78·7	85·8
Resin	8·3	9·1
Proteid	2·8	3·1
Insoluble matter ...	1·8	2·0
Ash	0·63	0·69

The rubber was valued at 2*s*. 8*d*. to 2*s*. 9*d*. per lb. in this country, with fine hard Para at 4*s*. 6*d*. per lb., and Benin lump rubber at 2*s*. to 2*s*. 1*d*. per lb.

The results of the investigation show that these three samples of Funtumia rubber are of very fair quality, and it is evident that if prepared in this form the rubber will realise much higher prices than ordinary Benin Lump rubber.

Sample A, prepared under the supervision of the Forest Officer, was the best of the series, both as regards chemical composition and appearance, but was closely followed by B. Sample C, prepared by the natives, contained a larger amount of proteid and insoluble matter than the other two specimens, and the percentage of caoutchouc is correspondingly reduced; it was also much rougher in appearance and had not been dried so thoroughly. For these reasons its value is a little lower than that of the other samples.

The preparation of Funtumia rubber in the form of sheets is a great improvement on the usual native methods, and should be encouraged as far as possible.

IV.—*Benin Lump Rubber* (1908).

Two specimens of this rubber have been examined:—

No. 1. Weight, 8¼ lb.

The sample consisted of two large lumps and one thick biscuit of rubber, which were dark coloured and dirty externally, but white, porous and very moist within. The rubber was soft and had a very disagreeable odour; its physical properties were, however, fairly good.

A chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	22·3	—
Caoutchouc	63·8	82·1
Resin	6·8	8·7
Proteid	5·1	6·6
Insoluble matter ...	2·0	2·6
Ash	0·63	0·82

The rubber was valued at 1*s*. 10*d*. to 1*s*. 11*d*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This sample is an average specimen of ordinary "Benin Lump" rubber.

No. 2. Weight, 7 lb.

The sample consisted of three large and three small lumps, which were all dark coloured and dirty externally. Some of the lumps were fairly dry throughout, whereas others were white and very moist internally. The rubber was rather weak and "dead"; it had a very unpleasant odour.

The results of the chemical examination are given in the following table:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	6·5	—
Caoutchouc	58·9	63·0
Resin	19·7	21·1
Proteid	7·2	7·7
Insoluble matter ...	7·7	8·2
Ash	1·57	1·68

The rubber was valued at 1*s*. 6*d*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This is a sample of ordinary "dead" Benin Lump rubber, containing a large percentage of resin.

V.—'*Anyo*' *Rubber from* Funtumia elastica (1908).

The sample consisted of 14 biscuits of rubber ranging from 4 to 7 inches in diameter and from ⅜ to 1 inch in thickness, and weighing 6 lb. The biscuits were dark coloured externally, and covered with mould on arrival; internally they were white and moist. The rubber exhibited good elasticity and tenacity.

The analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·6	—
Caoutchouc	82·5	86·5
Resin	7·5	7·8
Proteid	4·2	4·4
Insoluble matter ...	1·2	1·3
Ash	0·52	0·55

The specimen was valued at 2*s*. 6*d*. to 2*s*. 8*d*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This rubber is of good quality and if carefully prepared would realise very satisfactory prices. It would be an advantage to make the biscuits thinner, so that the rubber could be thoroughly dried before export. The mouldy condition of the sample on arrival and the slight stickiness of some of the biscuits were no doubt due to the rubber having been packed before it was completely dry.

VI.—Funtumia elastica *Rubber prepared by Boiling* (1910).

The sample weighed about 13 oz. and consisted of a large piece of sheet rubber about ⅛ inch thick, almost black in colour, and sticky externally. The elasticity and tenacity were fairly good.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·5	—
Caoutchouc	86·8	87·2
Resin	10·2	10·3
Proteid	1·8	1·8
Insoluble matter ...	0·7	0·7
Ash	0·5	0·5

Owing to its sticky character the rubber was not suitable for commercial valuation. Rubber of similar composition and properties, but free from stickiness, would probably realise from 7*s.* to 7*s.* 3*d.* per lb. in this country, with fine hard Para quoted at 10*s.* per lb.

This rubber is fairly satisfactory in composition although the percentage of resin is a little high. It appears, however, to have been over-heated either during preparation or subsequently, with the result that it has become sticky and depreciated in value.

VII.—Funtumia elastica *Biscuits* (1910).

The sample weighed about 14 oz. and consisted of 12 small biscuits of light-brown rubber, rather rough in appearance, but clean and well prepared. Most of the biscuits were thoroughly dry, but a little moisture was present in some of the thicker biscuits, which were marked with opaque patches. The elasticity and tenacity of the rubber were very good.

A chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·4	—
Caoutchouc	88·0	88·4
Resin	9·0	9·0
Proteid	2·2	2·2
Insoluble matter ...	0·4	0·4
Ash	0·4	0·4

The rubber was valued at 8*s.* per lb. in London with fine hard Para at 10*s.* 6*d.* per lb., and Lagos and Benin Lump (selected) at 4*s.* 11*d.* to 5*s.* 3*d.* per lb.

This rubber is of satisfactory composition, containing over 88 per cent. of caoutchouc in the dry material. The percentage of resin is, however, a little high.

It will be seen from the valuation obtained that this Funtumia biscuit rubber would realise about 3*s*. per lb. more than selected Lagos and Benin Lump rubber.

NORTHERN NIGERIA.

Ire Rubber (native) from Funtumia elastica (1906).

The sample weighed 6 oz. and consisted of an irregularly-shaped piece of rubber which had been cut from a large block. It was black externally but lighter within, sticky on the surface, and had a disagreeable odour. The rubber was very deficient in elasticity and tenacity.

The results of the chemical examination were as follows:—

	Per cent.
Moisture	6·4
Caoutchouc	46·4
Resin	36·2
Proteid	4·7
Insoluble matter	6·3
Ash	5·7

It is clear from these figures that the rubber is of very resinous character and consequently of low value. The rubber is not the pure product of *Funtumia elastica* latex, but has evidently been adulterated by the admixture of resinous latex.

LIBERIA (1906).

Three samples of lump rubber obtained from Liberia have been examined at the Imperial Institute. It was stated that one of the samples, marked L. R. C./B. 2, represented the bulk of the rubber shipped from Grand Bassa, and that the other two samples, marked ex Batanga, L. R. C./S. R. 3 and 4, were obtained from Sino.

No. 1. L. R. C./B. 2 from Grand Bassa, Liberia.

This sample weighed 1 lb. 11 oz. and consisted of three irregular pieces of rubber which were almost black externally and possessed a strong fœcal odour. The lumps were grey externally and contained a considerable amount of water. The rubber exhibited very good elasticity and tenacity.

No. 2. L. R. C./S. 3 from Sino, Liberia.

This sample weighed 12 oz. and consisted of four thick slices of rubber which had evidently been cut from an irregular lump. The rubber was very dark coloured and possessed a putrescent odour; it was strong and elastic.

No. 3. L. R. C./S. R. 4 from Sino, Liberia.

This sample weighed 1 lb. and consisted of several thick slices of rubber cut from a large irregular lump. The rubber was dark brown and possessed a strong odour; its physical properties were very satisfactory.

Results of Examination.

The samples were submitted to chemical examination, with the following results:—

	Rubber as received.			Composition of dry rubber.		
—	L.R.C. B. 2.	L.R.C. S.R. 3.	L.R.C. S.R. 4.	L.R.C. B. 2.	L.R.C. S.R. 3.	L.R.C. S.R. 4.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	19·6	5·3	15·0	—	—	—
Caoutchouc	71·7	68·8	68·9	89·2	72·6	81·1
Resin	5·8	11·3	5·6	7·2	12·0	6·6
Proteid	1·8	7·1	5·3	2·2	7·5	6·2
Insoluble matter ...	1·1	7·5	5·2	1·4	7·9	6·1
Ash	1·20	0·84	0·93	1·49	0·9	1·1

From a comparison of these results it will be seen that, so far as chemical composition is concerned, sample "L. R. C./B. 2" is the best of the three specimens. When dry this sample contained nearly 90 per cent. of caoutchouc and a little over 7 per cent. of resin, whilst the amounts of proteid and insoluble matter are low. The other two specimens, of which "L. R. C./S. R. 4" is the better, contain rather large percentages of proteid and insoluble matter, and the amount of resin present in "L. R. C./S. R. 3" is high. In these two cases the rubber could be greatly improved by more careful preparation, which would reduce the percentage of insoluble matter and probably that of the proteids as well, with the result that the percentage of caoutchouc would be considerably raised.

Samples L. R. C./B. 2 and L. R. C./S. R. 4, as received, contained rather large percentages of moisture.

Conclusions.

Although satisfactory in composition and in physical properties these rubbers from Liberia possess very objectionable odours. This feature may be due to the methods of preparation adopted by the natives or to the fermentation of the proteids present, although it must be observed that sample L. R. C./B. 2 which had a very disagreeable odour only contained a small percentage of proteid.

There is little doubt that the quality of these rubbers would be considerably improved by the introduction of better methods of preparation, and the processes employed by the natives should be carefully investigated with this object in view.

Uganda.

Funtumia elastica *Rubber from the Budongo Forest* (1906).

The specimen consisted of a thin biscuit of rubber weighing about 3 oz. The rubber was dark coloured, but was otherwise satisfactory in appearance. It was free from vegetable impurity, had only a slight surface stickiness, and exhibited very good elasticity and tenacity.

The chemical examination furnished the following results:—

	Per cent.
Moisture	1·7
Caoutchouc	84·6
Resin	6·4
Proteid	6·5
Ash	0·8

The analysis shows that so far as chemical composition is concerned the rubber is of good quality, although the percentage of proteid is a little high and above that found in some samples of *Funtumia elastica* rubber which have been forwarded to the Imperial Institute from West Africa.

The sample was submitted to brokers who valued it at 5*s*. 6*d*. or 5*s*. 7*d*. per lb. in London, with fine hard Para quoted at 5*s*. 5*d*. per lb., and plantation Para biscuits at 6*s*. 3*d*. per lb.

TRINIDAD.

I.—*Two Samples of Funtumia Rubber* (1903).

Two small samples of rubber, derived respectively from *Funtumia africana* and *Funtumia elastica*, under cultivation in Trinidad, were forwarded to the Imperial Institute by the Superintendent of the Royal Botanic Gardens at the instance of the Government of Trinidad. It was stated that the specimens were obtained from seedlings of the two species, 3 years old, and with stems about 3 inches in diameter, and that the latex was coagulated by the addition of alcohol.

No. 1. Rubber from *Funtumia africana,* Stapf.

The specimen was forwarded between watch glasses. It was a very soft, sticky mass, which adhered to the fingers and pulled out in long fine threads; it had a brownish colour externally, but was whitish within.

No. 2. Rubber from *Funtumia elastica,* Stapf.

This was a small piece of soft and sticky rubber of dark brown colour; it exhibited good elasticity and fair tenacity. It was much superior in physical characters to the preceding specimen.

The following results were obtained on analysis:—

—	—	Composition of the dry rubber for comparison.		
	Moisture.	Caoutchouc.	Resin.	Insoluble matter.
	Per cent.	Per cent.	Per cent.	Per cent.
1. *Funtumia africana.*	20·7	39·3	60·0	0·7
2. *Funtumia elastica...*	15·1	80·4	15·3	4·3

It will be seen from these figures that the sample of rubber from *Funtumia africana* is greatly inferior to that from *Funtumia elastica,* containing nearly four times as much resin and only half as much caoutchouc as the latter. As the trees

of both species were of the same age, this difference in the product appears to be characteristic, and confirms the opinion arrived at in West Africa regarding the value of the two species.

II—*Samples of Funtumia Rubber* (1903).

These samples of Funtumia rubber were prepared by the Superintendent of the Royal Botanic Gardens in Trinidad from 4½ year old trees, and were forwarded to the Imperial Institute for chemical examination and commercial valuation. The two specimens had been prepared by different methods.

Description of Samples.

No. 1. "350 c.c. Funtumia latex from trees 4½ years old. This was coagulated with a sufficient quantity of alcohol added gradually and produced 270 grams of wet rubber. 'Wet rubber' is rubber just after coagulation. It drains considerably afterwards, and probably loses 15 to 20 per cent. in weight."

The specimen consisted of two pieces of rubber each approximately 4 in. by 3 in., and together weighing 8⅛ oz. On arrival they were light brown externally, but darkened considerably on keeping; when cut they were slightly porous and quite moist within, but contained no uncoagulated latex; the colour of the freshly-cut surface was a light cinnamon brown, and showed the presence of only a trace of foreign matter. The rubber was soft and slightly sticky, very elastic, but rather deficient in tenacity.

No. 2. "50 c.c. of latex of *Funtumia elastica* from trees 4½ years old. Coagulated with heat over lamp. Obtained 42·8 grams of rubber."

The specimen was a small ball of rubber weighing about 1½ oz. It was light brown externally, but darkened on keeping; within it was quite white, porous, and contained a considerable quantity of uncoagulated latex. The ball was therefore cut into slices and allowed to dry in the air before analysis. The rubber was rather soft, but very elastic and tenacious, and only slightly sticky.

Results of Examination.

The results of the analysis of the specimens are given in the following table:—

—	Rubber as received.		Composition of dry rubber.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	29·5	21·2*	—	—
Caoutchouc	60·2	68·5	85·3	86·9
Resin	7·9	7·9	11·2	10·0
Insoluble matter ...	2·4	2·4	3·5	3·1
Ash	1·37	2·08	1·94	2·66

* This specimen was air-dried before analysis.

The samples are very similar in composition, and the figures show that they are of very fair quality although the percentages of resin are a little high. Both samples were very wet when received, and No. 2 which had been prepared by heating, contained a considerable quantity of uncoagulated latex.

Commercial Value.

The specimens were submitted to brokers who valued No. 1 at 2*s*. 6*d*. per lb., and No. 2 at 2*s*. 2*d*. per lb. in London, with fine hard Para quoted at 4*s*. 2*d*. per lb.

It appears, therefore, from these experiments, that the trees of *Funtumia elastica* under cultivation in Trinidad, will yield a marketable rubber at the age of 4½ years.

III.—Funtumia elastica *Rubber coagulated by Boiling* (1907).

This rubber was stated to have been collected from 7½ year old trees.

The sample consisted of a small oval piece of black rubber, clean, well prepared and free from stickiness; it exhibited fair elasticity and tenacity.

The following results were obtained on analysis:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·2	—
Caoutchouc	84·8	87·6
Resin	8·7	9·0
Proteid	2·6	2·7
Insoluble matter ...	0·7	0·7
Ash	0·71	0·73

This rubber is of very fair quality, although it is not very strong, and the percentage of resin is a little high. The specimen was valued at 3*s*. 8*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

RUBBER OF *FICUS ELASTICA*, Roxb., AND OF OTHER SPECIES OF FICUS.

The genus Ficus, belonging to the natural order Moraceae, includes a number of trees which furnish rubber or rubber-like material. The principal rubber-yielding species is *Ficus elastica*, Roxb., the Assam rubber tree, but several other species also furnish rubber of good quality. Other species, including the African *F. Vogelii*, Miq., yield a resinous rubber of inferior quality, whilst others again, such as *F. platyphylla*, Del., give a hard resinous product which exhibits a superficial resemblance to gutta percha.

Ficus elastica, Roxb.

This tree is a native of India where it occurs on the lower slopes of the Himalayas from Nepal eastwards to Assam, and thence extends southwards into Burma and the Malay Peninsula and Archipelago. In Assam it grows at elevations of from 1,000 to 3,000 feet, and is sometimes found up to 5,000 feet; the finest specimens are stated to occur in hilly country up to a height of 2,500 feet.

It is, when fully grown, a gigantic tree which usually sends down numerous aerial shoots from its branches. At first it is frequently epiphytic on another tree, which, however, is usually killed, sooner or later, by the enveloping aerial roots. Trees of *Ficus elastica* from 100 to 120 feet high are of frequent occurrence in the forests.

The cultivation of *Ficus elastica* has been undertaken in Assam and Southern India, and also on a large scale in Java and Sumatra. Plantations of the tree were established in the Federated Malay States, but in that country its cultivation has been generally abandoned as the Para tree has been found to be much more satisfactory. The latter tree is easier to tap, can be tapped at an earlier age, gives a steady yield of latex, and furnishes rubber of better quality.

Ficus elastica has been introduced into many tropical countries, but it does not appear likely that it will prove to be an important source of rubber except perhaps in its natural habitat.

On the Assam plantations the latex is allowed to coagulate spontaneously either on the trunk or on bamboo mats placed on the ground so as to catch the latex which overflows from the incisions. These two classes of rubber are known as "tree" and "mat" rubber respectively. The bulk of the *Ficus elastica* rubber exported from Assam is collected by the natives from wild trees. On the plantations in the Netherlands East Indies, the *Ficus elastica* rubber is prepared by machinery in the form of sheet, crêpe, and block.

Specimens of *Ficus elastica* rubber from Madras, Assam, Gold Coast, Southern Nigeria, and Seychelles, have been examined at the Imperial Institute.

Ficus Vogelii, Miq.

This tree is a native of West Africa, and extends from the Gambia into Nigeria. The latex, which flows freely when incisions are made in the bark, is of very resinous character and consequently yields a rubber of inferior quality. At present this tree is scarcely utilised as a source of rubber by the natives except in Northern Nigeria. In the latter country the product known as "Niger balata" is prepared from it.

Specimens of the rubber of *Ficus Vogelii* from the Gambia, Gold Coast, and Northern Nigeria, have been examined at the Imperial Institute, and the results are recorded in the following section.

Ficus platyphylla, Del.

This tree occurs in Northern Nigeria and thence extends eastwards to the Bahr-el-Ghazal. It furnishes a resinous product which on drying becomes hard. In physical properties the material resembles gutta percha more than rubber, but it contains a quantity of inferior caoutchouc and no gutta.

Specimens of the product from Nigeria and the Bahr-el-Ghazal have been examined at the Imperial Institute.

RUBBER OF *FICUS ELASTICA*, Roxb.

India.

I.—Ficus elastica *Rubber from Parlakimedi, Madras* (1905).

This rubber was stated to have been obtained from *Ficus elastica* trees cultivated at Parlakimedi, Ganjam District, Madras.

The specimen consisted of a single flat cake weighing 2 oz. The rubber was black externally, but when the cake was cut open it was found to be white at the centre, the colour gradually darkening towards the surface. The rubber was fairly tenacious and elastic, somewhat moist but not sticky; it contained a small amount of visible impurity, consisting principally of vegetable débris.

The rubber was examined chemically, and gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·7	—
Caoutchouc	85·2	88·6
Resin	7·8	8·1
Proteid	1·4	1·4
Insoluble matter ...	1·9	1·9
Ash	0·5	0·5

These results show that the sample is of good quality, as the dry material contains over 88 per cent. of caoutchouc. The percentage of resin is lower than the amount frequently found in *Ficus elastica* rubber.

A sample of the rubber was submitted to commercial experts for criticism and valuation. They described it as "clean, strong rubber, worth from 3*s*. 6*d*. to 3*s*. 9*d*. per lb.," good quality Assam rubber derived from *Ficus elastica* being quoted at the same time at 3*s*. 7½*d*. per lb., and fine hard Para from South America at 5*s*. 2*d*. per lb.

II.—Ficus elastica *Rubber from the Charduar Plantations, Assam* (1905).

The sample was labelled "4 lb. rubber (class A) of 1903-4, Charduar rubber plantation." It consisted of a single brick-shaped block measuring 10 × 3 × 5 inches. The rubber was of fairly uniform reddish-brown colour, but showed here and there small white patches; it was clean, free from stickness, and exhibited good elasticity and tenacity.

A representative sample of the rubber was analysed with the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	0·9	—
Caoutchouc	76·7	77·5
Resin	19·2	19·3
Proteid	1·5	1·5
Insoluble matter ...	1·7	1·7
Ash	0·5	0·5

These results show that this rubber contains comparatively small quantities of proteid and insoluble matter, but an excessive amount of resin.

A representative sample of the rubber was submitted to a manufacturing firm in order that technical trials might be made with it. The firm reported that the rubber was clean and well prepared, showed a very small loss on washing, but contained an abnormally large quantity of resin, and for that reason would be unsuitable for general use as an insulator, though it could be used for the manufacture of ebonite. The value of the rubber for this purpose would be about 3*s*. 3*d*. per lb., compared with fine hard Para at 5*s*. 2*d*. per lb.

A sample of the rubber was also submitted to a firm of commercial experts for valuation. They described it as "fine red Assam rubber" worth from 3*s*. 8*d*. to 3*s*. 9*d*. per lb. on the London market, and stated that consignments of similar quality would be readily saleable.

III.—Ficus elastica *Rubber from Assam* (1907).

Two specimens of this rubber from the Kulsi Plantation in the Kamrup Division of Assam were submitted for analysis and valuation.

No. 1. "Tree Rubber from *Ficus elastica*."

The specimen consisted of an irregular cake of rubber formed by the aggregation of thin strips. The rubber was reddish-brown, clean, free from stickiness, and exhibited good elasticity and tenacity.

A chemical examination furnished the following figures:—

	Per cent.
Moisture	0·7
Caoutchouc	78·0
Resin	19·0
Proteid	0·9
Insoluble matter	1·4
Ash	0·49

The rubber was valued at 4s. 3d. to 4s. 6d. per lb. in London, the current price of fine hard Para from South America being 5s. 2d. per lb.

The percentage of resin in this rubber is higher than is desirable, but otherwise it is of satisfactory quality and would be readily saleable.

No. 2. "Mat Rubber from *Ficus elastica.*"

This was a small piece of dark-brown rubber composed of several thin sheets firmly attached together. The rubber was soft, sticky, and rather weak.

The rubber was found to have the following composition:—

	Per cent.
Moisture	2·1
Caoutchouc	80·0 (including proteid)
Resin	16·0
Insoluble matter	1·9
Ash	1·94

The specimen was valued at 2s. to 2s. 3d. per lb. in London, with fine hard Para quoted at 5s. 2d. per lb., but it would be difficult of sale on account of its soft, sticky character.

The sample was too small for complete chemical examination, and consequently it was not possible to determine the amount of proteid present. The latter constituent is included with the "caoutchouc."

This rubber contains a little less resin than the "tree rubber," but on account of its weak, sticky character it is much inferior in value. The stickiness may be due to the plan of placing the mats covered with rubber in the sun to dry. It would be preferable to effect the drying in the shade so as to avoid overheating the rubber.

IV.—Ficus elastica *Rubber from Madras* (1908).

Two specimens of this rubber obtained at Mukkie in the Kanoth Range, North Malabar, have been examined.

No. 1. *Ficus elastica,* scrap rubber.

A cylindrical lump of reddish-brown rubber, made up of aggregated shreds, and weighing 12½ oz. The rubber was clean, free from stickiness, but rather weak.

The rubber had the following composition:—

	Per cent.
Moisture	0·9
Caoutchouc	67·3
Resin	28·1
Proteid	0·9
Insoluble matter	2·8
Ash	0·47

The sample was valued at 2*s*. 11*d*. per lb. in London, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This rubber contains an excessive amount of resin, which adversely affects its physical properties.

No. 2. *Ficus elastica*, biscuit rubber.

A large circular biscuit of black rubber weighing 8 oz. The rubber was clean, free from stickiness, but deficient in elasticity and tenacity.

A chemical examination gave the following results:—

	Per cent.
Moisture	4·0
Caoutchouc	71·2
Resin	22·7
Proteid	1·0
Insoluble matter	1·1
Ash	1·68

The specimen was valued at 2*s*. 5*d*. per lb. in London, with fine hard Para from South America quoted at 3*s*. 5½*d*. per lb.

This sample contains a little less resin than the preceding specimen, but on account of its dark colour it would not realise such a good price.

Gold Coast.

Ficus elastica *Rubber from Aburi* (1906).

This sample of rubber was prepared from trees growing in the Botanic Gardens at Aburi. It weighed about 2 oz., and consisted of aggregated shreds of rubber, which varied in colour from light brown to red, the latter predominating; a small amount of vegetable impurity was present. The rubber exhibited very good elasticity and tenacity.

The results of the chemical examination were as follows:—

	Per cent.
Moisture	1·5
Caoutchouc	80·1
Resin	11·6
Proteid	2·6
Insoluble matter	4·2
Ash	1·12

The rubber is therefore of very fair quality, containing 80 per cent. of caoutchouc, though the percentage of resin is a little high.

It was valued at from 4*s*. 3*d*. to 4*s*. 6*d*. per lb. in London, with fine hard Para at 5*s*. 4*d*. per lb.

SOUTHERN NIGERIA.

Rubber of Ficus elastica (1909).

A thin sheet of black rubber which was sticky on the surface. The rubber was weak and tore readily when stretched.

An analysis gave the following results:—

	Per cent.
Moisture	0·3
Caoutchouc	90·2
Resin	8·1
Proteid	1·0
Ash	0·4

The rubber is of uncertain value but might be worth about 3*s*. per lb. in London, with fine hard Para quoted at 5*s*. per lb.

This rubber is very satisfactory in chemical composition, but its poor physical properties greatly depreciate its value. No information was supplied as to the age of the tree from which the rubber was obtained, nor as to the method of preparation employed, so that it is not possible to express any opinion regarding the probable cause of the deficiency in strength. If the physical properties of this rubber could be improved, it would be of very good quality and would realise a very satisfactory price in the market.

SEYCHELLES.

I.—*Coagulated latex of* Ficus elastica (1903).

The specimen was a porous mass of rubber which was perfectly white when received but turned brown on exposure to the air, becoming at the same time translucent and slightly sticky. The rubber was soft and tore readily when stretched.

The dry rubber had the following composition:—

	Per cent.
Caoutchouc	88·0
Resin	11·6
Insoluble matter	0·4

The analysis showed that the rubber was of very fair quality, containing 88 per cent. of caoutchouc, but owing to the method of preparation employed, its physical characters were unsatisfactory, and the sample was not suitable for commercial valuation.

II.—Ficus elastica *Latex coagulated by heating at* 100° *C. and dried in the shade* (1904).

This was a flat strip of rubber weighing 2 oz. It had a distinct purplish colour, which was most pronounced on the outside. The rubber was not sticky, but was very deficient in elasticity and tenacity, and was evidently of rather inferior quality.

An analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	8·6	—
Caoutchouc	45·3	49·6
Resin	44·6	48·8
Insoluble matter ...	1·5	1·6
Ash	0·21	0·23

The rubber is therefore of poor quality, containing almost equal proportions of caoutchouc and resin. In the absence of detailed information regarding the experiments, it is impossible to indicate the reason for the high percentage of resin, but the explanation may possibly be that the latex was obtained from young trees. The preceding sample of *Ficus elastica* rubber from Seychelles was of much better quality, so far as chemical composition is concerned, than that now under notice, as it contained 88 per cent. of caoutchouc and 11·6 per cent. of resin.

Although the rubber was not very satisfactory, either in composition or in properties, it was submitted to brokers for valuation. They reported that consignments of similar quality might possibly realise about 2*s*. per lb. in London, but they pointed out that this valuation must be regarded as only approximate. Fine hard Para rubber was quoted at 4*s*. 8*d*. per lb. on the same date.

RUBBER OF *FICUS VOGELII*, Miq.

Gambia.

I.—*Coagulated Latex of Common Fig Tree* (1907).

The accompanying botanical specimen of the tree yielding this rubber was identified at Kew as *Ficus Vogelii*, Miq. The specimen, which weighed $2\frac{1}{2}$ lb., consisted of a large ball of reddish-brown rubber, six inches in diameter, sticky internally, and containing a small amount of bark. The rubber exhibited fair elasticity and tenacity when examined in bulk, but small pieces could be readily torn in the fingers.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·0	—
Caoutchouc	62·7	65·3
Resin	28·6	29·9
Proteid	1·0	1·0
Insoluble matter ...	3·7	3·8
Ash	0·43	0·44

The commercial value of this rubber cannot be determined exactly without technical trials, but brokers stated that it might realise about 3*s*. per lb. in London, the current price of fine hard Para from South America being 4*s*. 7*d*. per lb.

The rubber contains a large amount of resin which adversely affects its physical properties. The percentage of resin is, however, much less than has been found in other specimens of *Ficus Vogelii* rubber which have been received at the Imperial Institute from West Africa.

II.—*Rubber of* Ficus Vogelii (1908).

The results of the examination at the Imperial Institute of the preceding sample of the rubber of *Ficus Vogelii*, Miq. from the Gambia, showed that the product was of resinous nature, but that it might be suitable for certain technical purposes. Larger specimens were, therefore, requested in order that manufacturing trials might be made, and as a result the samples dealt with in this report were forwarded for further examination.

Description of Samples.

No. 1. From the Kommbo district. Weight, 15 lb.

The sample consisted of two large balls of pale brown scrap rubber, which contained a fair amount of vegetable impurity. The rubber was slightly moist in places and obviously very resinous; its elasticity and tenacity were poor.

No. 2. From the Bathurst district. Weight, 81 lb.

This consisted of a number of thick cakes of rubber, which were very dark externally, but slightly moist and reddish-brown within. The rubber obviously contained a large amount of resin and exhibited poor elasticity and tenacity.

Results of Examination.

The results of the chemical examination of the rubbers are given in the following table:—

—	Rubber as received		Composition of dry rubber.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	4·4	7·3	—	—
Caoutchouc	58·0	61·2	60·6	65·9
Resin	33·8	29·5	35·4	31·8
Proteid	1·4	1·2	1·5	1·4
Insoluble matter ...	2·4	0·8	2·5	0·9
Ash	0·5	1·3	0·6	1·4

It will be seen from these figures that the two specimens are similar in composition, but No. 2 is slightly superior in quality to No. 1.

Technical Trials.

The two samples of rubber were submitted to rubber manufacturers for technical trial and commercial valuation, with the following results:—

One firm reported that after a careful examination they found that the rubber from the Bathurst district (No. 2) was somewhat better than that from the Kommbo district (No. 1). The loss on washing was 6·2 per cent. in the case of the former, and 7·1 per cent. in the latter. They valued the washed rubber from No. 2 at 1*s*. 11*d*. per lb., and that from No. 1 at 1*s*. 7*d*. per lb., with fine hard Para rubber quoted at 2*s*. 9*d*. per lb.

A firm of cable manufacturers reported that this rubber could not be employed for their purposes, but might be useful in other branches of the industry. They stated that the rubber is very sticky in working and possesses very little elasticity or resilience; the stickiness, moreover, increases as the rubber is worked.

Conclusions.

These two samples of *Ficus Vogelii* rubber correspond fairly closely in composition with the previous specimen forwarded from the Gambia. It is evident that the rubber is of very resinous character, the three samples examined containing 29·9, 35·4, and 31·8 per cent., respectively, of this constituent, but the results of the manufacturers' trials show that the product could be utilised for certain technical purposes, and that if well prepared it will realise a very fair price in the market. The tree, therefore, appears to deserve attention if it is sufficiently abundant to furnish commercial supplies of rubber.

GOLD COAST.

I.—*Rubber of* Ficus Vogelii (1906).

This sample of rubber was forwarded to the Imperial Institute in order that its composition and commercial value might be ascertained. It was stated that the rubber was derived from *Ficus Vogelii*, a tree indigenous in the Colony, though little used by the natives as a source of rubber, and it was recognised that the product was of rather inferior quality.

The sample was small, weighing only 2¼ oz., and consisted of a thin sheet of rubber. It was light brown, slightly sticky, and very deficient in elasticity and tenacity.

The chemical examination gave the following percentage results:—

	Per cent.
Moisture	0·4
Caoutchouc	51·6
Resin	44·0
Proteid	3·5
Insoluble matter	0·5
Ash	0·14

It is clear from these figures that the rubber is of very inferior quality on account of the large percentage of resin present, and material of similar character would only fetch a low price in the market. The sample was submitted for the opinion of brokers, who reported that it was very gummy and non-elastic and would be of uncertain value. They considered that it would probably not be worth more than about 6*d*. per lb. in London, with fine hard Para quoted at 5*s*. 5*d*. per lb.

II.—*Rubber of* Ficus Vogelii (1907).

This sample of *Ficus Vogelii* rubber was prepared by boiling the latex obtained from trees growing in the Botanic Gardens at Aburi. It consisted of a number of thin cakes of brownish rubber, which together weighed 4 oz. From its physical characters the rubber was evidently of inferior quality, being soft and slightly sticky, and deficient in elasticity and tenacity.

The results of the chemical examination are given in the following table:—

	Per cent.
Moisture	1·0
Caoutchouc	51·8
Resin	44·0
Proteid	2·3
Ash	0·9

The specimen was therefore almost identical in composition with the preceding sample, the only notable difference being that it contained less proteid and more ash than the latter. It is evident that the rubber is of inferior quality, as both specimens contained 44 per cent. of resin and only a little over 50 per cent. of caoutchouc.

The present specimen, although rather soft and deficient in elasticity and tenacity, was superior in physical properties to the earlier sample. It was submitted for valuation to brokers, who stated that it was exceedingly difficult to fix a price for such material, but they expressed the opinion that a consignment of similar quality might fetch about 2*s*. per lb. in London, with fine hard Para at 5*s*. 4*d*. per lb. They added that the present sample was a great improvement on the previous specimen which they valued at 6*d*. per lb.

III.—*Rubber prepared from the Latex of* Ficus Vogelii (1907).

A circular biscuit of brown rubber, the surface of which was almost covered with a peculiar white deposit which appeared crystalline when viewed with a microscope. The rubber was exceedingly weak and was evidently of inferior quality.

	Rubber as received. Per cent.
Moisture	0·8
Caoutchouc	60·6
Resin	35·6
Proteid	1·7
Ash	1·3

This sample of *Ficus Vogelii* rubber was of rather better quality than the two previous specimens from the Gold Coast, examined at the Imperial Institute. The percentage of resin was lower, and that of caoutchouc correspondingly higher.

The sample was submitted to brokers who stated that the rubber might realise from 2*s*. to 2*s*. 6*d*. per lb. in London, with fine hard Para at 4*s*. 7*d*. per lb., but that its value was uncertain.

The rubber furnished by this tree is of inferior quality on account of the large percentage of resin which is usually present. It was suggested however that it would be well to forward a trial consignment of about 56 lb. of the rubber to the Imperial Institute for technical trial.

IV.—*Rubber of* Ficus Vogelii (1910).

This small consignment of *Ficus Vogelii* rubber was forwarded to the Imperial Institute in order that further manufacturing trials might be made to determine the possibility of utilising this rubber for technical purposes.

Description of Consignment.

Two qualities of rubber, " light " and " dark," were included in the consignment.

No. 1. " Memluku " Rubber (light). Weight 39½ lb.

The sample was in the form of light-brown biscuits, which were well-prepared and free from stickiness. The rubber evidently contained a large proportion of resin, being soft and very weak.

No. 2. " Memluku " Rubber (dark). Weight 14½ lb.

The sample consisted of fairly thick, almost black biscuits, which were not so well prepared as the preceding specimen, and contained a small quantity of vegetable impurity. The rubber was of resinous nature, being soft, rather sticky, and deficient in elasticity and tenacity.

Results of Examination.

The two samples gave the following results on analysis:—

	No. 1 (light). Per cent.	No. 2 (dark). Per cent.
Loss on washing and drying ...	0·7	3·0
Composition of dry washed rubber:—		
Caoutchouc	66·2	65·5
Resin	31·6	30·9
Proteid	1·9	2·5
Ash	0·3	1·1

The two specimens are therefore very similar in composition; the dark sample, No. 2, contains more proteid and ash than sample No. 1, but a little less resin.

Three previous samples of *Ficus Vogelii* rubber from the Gold Coast have been examined at the Imperial Institute. Two of these contained 44 per cent. of resin, and the third 35·6 per cent. of this constituent. Three specimens of *Ficus Vogelii* rubber from the Gambia contained 29·9, 35·4, and 31·8 per cent. of resin, respectively.

Technical Trials.

The rubber has been submitted to technical trials by manufacturers, who report that both the light and dark samples are soft and of inferior quality. Sample No. 1 (light) was valued in a washed condition at about one-fifth the value of washed Para, say about 1*s*. 4*d*. per lb., with fine hard Para quoted at 6*s* per lb. Sample No. 2 when washed would be worth a little more than sample No. 1, say 1*s*. 6*d*. per lb.

The manufacturers added that in their opinion if the price of plantation Para rubber were to fall to 3*s*. per lb. this *Ficus Vogelii* rubber would not be marketable at more than 6*d*. to 7*d*. per lb.

For comparison with these valuations it may be noted that in November, 1908, the same manufacturers valued two specimens of *Ficus Vogelii* rubber, from the Gambia, at 1*s*. 7*d*. and 1*s*. 11*d*. per lb. (washed), with fine hard Para at 2*s*. 9*d*. per lb.

It would thus appear that the present samples from the Gold Coast are not of such good quality from the manufacturers' point of view as those received from the Gambia, with which, however, they closely agreed in composition.

In view of this report it does not appear desirable to take any steps at present to extend the collection of *Ficus Vogelii* rubber by the natives in the Gold Coast.

NORTHERN NIGERIA.

Balata Rubber from Ficus Vogelii (1906).

The sample weighed 2 lb. and consisted of a large square piece of rubber, brown externally but of a pinkish tinge within. The rubber was sticky in parts and was evidently of resinous character, although it exhibited fair elasticity and tenacity.

An analysis showed it to have the following composition:—

	Per cent.
Moisture	2·7
Caoutchouc	57·9
Resin	35·6
Proteid	1·8
Insoluble matter	2·0
Ash	1·7

It will be seen from this analysis that the material agrees generally in composition with the *Ficus Vogelii* rubber from the Gambia and the Gold Coast.

RUBBERS OF *FICUS* SPP.

LATICES OF *Ficus comosa* AND *Ficus indica* FROM INDIA (1905).

These specimens of the latices of *Ficus comosa* and *Ficus indica* were forwarded to the Imperial Institute by the Director of the Royal Botanic Gardens, Calcutta, and although the products furnished by these two species of *Ficus* are of little economic value, it may be useful to record the results of the chemical examination. Both specimens had undergone change during the journey, and were more or less completely coagulated on arrival, so that no experiments could be made on the actual latices.

Description of Samples.

LATEX OF *Ficus comosa.*—The sample consisted originally of about 200 c.c. of latex but coagulation had occurred during transit and a quantity of solid material had separated, leaving a slightly milky liquid. Both solid and liquid possessed an extremely unpleasant odour.

The solid matter was removed and dried by exposure on a porous tile, when it formed a dark-brown coherent mass, which was hard and sticky, and weighed about 20 grams. When placed in warm water it became soft and sticky, but returned to its hard condition on cooling.

Experiments were made with the fluid portion of the sample, but no further coagulation could be induced by any of the usual methods.

LATEX OF *Ficus indica.*—This sample had undergone coagulation, and was quite solid on arrival. The substance was dried by exposure on a porous tile, and was obtained as a buff, friable material, which became soft and somewhat elastic on immersion in warm water but hardened on cooling.

Results of Examination.

The following figures give the results of the chemical examination of the dry materials:—

	Ficus comosa. Per cent.	*Ficus indica.* Per cent.
Caoutchouc	9·9	7·3
Resin	82·6	79·1
Insoluble matter	7·5	13·6
Ash	1·1	1·4

These results show that both products consist essentially of resin; the small quantity of caoutchouc present was of very poor quality, being soft, sticky, and deficient in elasticity and tenacity.

PRODUCT OF *Ficus rubra* FROM SEYCHELLES (1904).

The *Ficus rubra* is known as "Lafouche" in Seychelles, where the tree is very abundant. It is stated to yield an enormous amount of latex, which coagulates freely and furnishes a very high percentage of the "rubber."

The sample, which had been prepared by heating the latex at 100° C., consisted of two circular cakes, each about 4 inches in diameter and ½ inch thick, together weighing 5 oz. Like many of the products yielded by other species of Ficus, the material resembled gutta percha rather than rubber in appearance and properties, but its relation to rubber was shown by the fact that it contained a small amount of inferior caoutchouc.

The cakes differed somewhat in appearance. One was a light pinkish colour, both externally and internally, and was rather hard and brittle, breaking with a short fracture. The other was dark chocolate-brown on the outside and dirty-white within; it was not so hard as the preceding specimen and showed a more granular structure. In composition and properties, however, the two cakes were practically identical.

The results of the analysis were as follows:—

	Per cent.
Moisture	0·1
Caoutchouc	15·9
Resin	82·5
Insoluble matter	1·5
Ash	0·23

The product from *Ficus rubra* is therefore of very inferior quality considered as a rubber, since it contains less than 16 per cent. of inferior caoutchouc and 82·6 per cent. of resin. As already noted, the material resembles gutta percha rather than rubber in properties, and in this respect, as also in composition, it agrees with the products yielded by many other species of Ficus. It would have no commercial value.

Ficus Rubber from Sierra Leone (1908).

The sample was labelled "*Ficus* sp." and weighed 3½ oz. It consisted of a thin sheet of brown rubber, and had apparently been smoked. The rubber was clean, slightly sticky and weak.

An analysis gave the following results:—

	Rubber as received. Per cent.
Moisture	0·4
Caoutchouc	59·4
Resin	37·1
Proteid	2·5
Insoluble matter	0·6
Ash	0·54

The rubber was of very resinous character, and would only realise a low price in the market.

Product of *Ficus* sp. from Nyasaland (1904).

The species of Ficus (*F. religiosa?*) from which the specimen was obtained is stated to occur all over Nyasaland; it attains a height of 30 to 40 feet, and is of a wide branching habit. On making incisions in the bark a white latex freely exudes, but does

not readily coagulate. The product submitted for examination was prepared by whipping the latex with a stick, when the solid matter separated as a sticky mass which resembled soft putty in consistence, and adhered to the hands unless kept wet.

The sample consisted of about 4 oz. of a soft sticky substance which could be readily moulded in the fingers. It exhibited very little elasticity or tenacity, and was evidently of a resinous nature.

The analysis furnished the following results:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	19·8	—
Caoutchouc	5·6	7·0
Resin	66·1	82·4
Insoluble matter ...	8·5	10·6
Ash	5·6	7·0

The product, therefore, consisted principally of resin, the percentage of this constituent being 82·4 in the dry material, whereas only 7 per cent. of inferior caoutchouc was present.

Material of this composition and character would possess little, if any, commercial value, as it could not be utilised for any technical purpose.

If the sample of the product now under notice can be taken as representative, it is very doubtful whether the tree will prove of economic value as a source of rubber or rubber-like material.

"Mpai" Rubber from Amatongaland, Natal (1904).

This sample of rubber was labelled "'Mpai' rubber, sample No. II., A. and M. 3839/1903," and had been obtained from Maputa, Amatongaland. In a minute by the Conservator of Forests, a copy of which was supplied, it is stated that the rubber is believed to be the product of a Ficus, the species of which has not yet been determined. The plant, however, is said to be identical with the tree referred to by the Amatongaland Rubber Commission under the native name of "Mfubu.' The Commissioners reported that this tree is only found in the heavily timbered swamps along the coast, principally around Kosi Bay, and they were of opinion that it would probably prove to be a most valuable rubber tree.

The sample of "Mpai" rubber submitted for examination consisted of a flat, elongated cake which weighed about 1¼ oz. It was light-brown externally, but the freshly-cut surface was less coloured and showed a pinkish tinge. The material could be easily indented with the finger nail, and exhibited very little elasticity but considerable tenacity; it had a somewhat fibrous structure, resembling that of gutta percha. When placed in warm water it softened a little without becoming sticky, and could then be readily drawn out to a considerable length, but the elasticity was only very slight.

The physical properties of the material seem to be intermediate between those of true rubber and gutta percha, a common feature of the products yielded by species of Ficus, but in composition, as shown by the analysis recorded below, it is much more closely related to rubber.

The chemical examination furnished the following results:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	28·4	—
Caoutchouc	19·6	27·4
Resin	49·9	69·6
Insoluble matter ...	2·1	3·0
Ash	0·79	1·10

The material, therefore, consists principally of resinous substances, which form 69·6 per cent. of the dry material, whilst only 27·4 per cent. of caoutchouc is present. The isolated caoutchouc was not very strong, but was quite free from stickiness.

The sample was submitted for commercial valuation to brokers, who were informed of its chemical composition. They reported that the material would be suitable for certain technical purposes, and that sales could probably be effected at about 10½*d*. or 11*d*. per lb., with fine hard Para at 4*s*. 4*d*. per lb.

PRODUCT FROM *FICUS PLATYPHYLLA*, DEL.

NORTHERN NIGERIA.

—"*Gutta Percha*" *from Bauchi Province* (1903).

The sample was stated to have been obtained from a place distant three days journey north-west of Bauchi. The sample consisted of a sheet of dark-brown material, 6 inches by 1 inch by ¼ inch, weighing about 1 oz. It was rather hard, but could be indented with the finger-nail, and it softened in the fingers, so that it could be readily moulded. It was rather sticky, and exhibited only slight elasticity and very little tenacity. When heated at 100° C. it melted almost completely and remained very sticky on cooling.

On chemical examination it was found to contain no true "gutta," the characteristic hydrocarbon of gutta percha, but yielded a substance possessing the physical properties of caoutchouc. It appeared, therefore, to be one of the pseudo-guttas which are more closely related in composition to rubber than to

gutta percha. An analysis by the method usually employed in the examination of a rubber gave the following results:—

	Per cent.
Moisture	2·5
Caoutchouc	15·1
Resin	74·9
Insoluble matter	7·5
Ash	3·48

The material, therefore, consists principally of resin, and would possess little commercial value.

II.—*From Kano* (1905).

The sample forwarded for examination consisted of a large cake weighing 4 lb. 6 oz. which had been purchased in the Kano market for 1*s*. 9*d*. It was stated in the accompanying letter, however, that traders in the Protectorate will not buy the material for export. The specimen consisted of a large flat cake formed by the aggregation of plaited strips of the material. It was dark reddish-brown in colour, slightly sticky, hard and fairly tenacious but devoid of elasticity. A small piece softened when held in the fingers and could then be moulded.

The material was evidently of resinous nature, and melted when heated at a temperature below 100° C.

An analysis gave the following results:—

	Per cent.
Moisture	8·9
Caoutchouc	9·8
Resin	75·2
Insoluble matter	6·1
Ash	4·3

These figures show that the two samples from Kano and Bauchi are very similar in composition, the only notable difference being in the amount of caoutchouc present. The caoutchouc isolated from the Kano specimen was slightly sticky, and although exhibiting moderate tenacity it was deficient in elasticity.

Material of this nature possesses little commercial value. Such products are only employed for mixing purposes, and, as the demand is limited, consignments are often difficult to sell.

III.—"*Gutta Percha*" *from Katsena, Northern Nigeria* (1907).

This sample of so-called "Gutta Percha" was procured in Lagos from certain traders from Katsena, in Northern Nigeria, who had brought down a load of 115 lb. of the material which was purchased as an experiment at 4½*d*. per lb. by one of the European firms.

The sample weighed 2 oz., and consisted of two plaited sticks of the material known as "Niger Gutta," or "Kano Rubber," derived from *Ficus platyphylla*, Delile. It was reddish-brown,

hard, inelastic, and possessed little tenacity. When held in the fingers or placed in warm water it softened and could be moulded, but hardened again on standing. The chemical examination of the material gave the following results:—

	Per cent.
Moisture	2·5
Caoutchouc	12·7
Resin	80·8
Proteid	1·1
Insoluble matter	2·9
Ash	1·96

The material is therefore of very resinous character, containing over 80 per cent. of that constituent, and only 12·7 per cent. of inferior caoutchouc.

Samples of this product from Kano and Bauchi have been already examined at the Imperial Institute, and the results of the previous analyses agree generally with those recorded above for the present specimen.

It is difficult to give a definite quotation for consignments of this material in England, as it is not usually sold in the open market. The gutta is used by certain rubber manufacturers for the production of special mixtures, but the demand is limited, and consignments offered in the market are often difficult to sell at remunerative prices.

SOUTHERN NIGERIA.

"*Balata or Gutta Percha*" (1904).

No information was supplied regarding the botanical source of this material, but from its appearance and character there can be little doubt that it was derived from *Ficus platyphylla*. The sample consisted of a number of irregularly-shaped pieces, formed by the aggregation of small rolls, and the total weight was 6 oz. Externally the material was reddish-brown in colour, but it was lighter within, and the cut surface showed whitish patches. It was sticky when handled, rather hard in the mass, but could be indented with the finger-nail; it exhibited very little tenacity, the small rolls breaking across when bent; small fragments softened, and were easily workable in the fingers. The material became quite soft and somewhat elastic when placed in hot water, and returned to its original condition on cooling.

The analysis of the material furnished the following results:—

	Per cent.
Moisture	3·7
Caoutchouc	13·2
Resin	78·5
Insoluble matter	4·6
Ash	1·9

Material of this type has only very limited uses, and its commercial value is consequently low. It cannot be employed as a

substitute for gutta percha, and its only application would probably be as a constituent of mixtures for the manufacture of low-grade rubber goods, for which purpose "Pontianac" is at present largely utilised in the United States.

SUDAN (1904).

Ficus platyphylla is very abundant in the Bahr-el-Ghazal Province of the Sudan, where the tree is known as "Kwell," "Fungo," and "Kubo" by the natives. Two specimens of the product obtained on boiling the latex, one prepared by the Officer commanding the Bahr-el-Ghazal and the other by natives, were received at the Imperial Institute for examination.

No. 1. Label: "Sample of 'Kwell' gutta percha boiled and dried by me.—E. H. A.—*Ficus platyphylla*."

The sample, which weighed about 2 oz., had been collected upon a stick. It was dark brown externally, but lighter within; in the mass the material was rather hard and brittle, but small pieces exhibited slight elasticity and tenacity. When placed in hot water it softened and became plastic, but hardened again on cooling.

No. 2. Label: "Sample of 'Kwell' gutta percha boiled and dried by natives.—*Ficus platyphylla*."

This specimen was a small rounded cake weighing about 3 oz. It was much more brittle than No. 1, which it otherwise resembled.

A chemical examination of the two specimens furnished the following results:—

	No. 1. Per cent.	No. 2. Per cent.
Moisture	4·4	8·8
Caoutchouc	24·5	18·8
Resin	67·2	64·1
Insoluble matter ...	3·9	8·3
Ash	1·1	3·6

It will be seen from these figures that the material consists largely of resin, the two specimens containing 64 and 67 per cent. of this constituent.

VINE RUBBER.

In addition to the trees already dealt with in the preceding pages there are a considerable number of climbing plants or vines (lianes) which furnish rubber. Nearly all these rubber-yielding vines belong to the natural order Apocynaceæ, the only other order represented among them being the Asclepiadaceæ (*Cryptostegia* spp.). They are widely distributed in tropical Africa and also occur in Asia, where they are found in India, the Malay Peninsula and Archipelago, and the neighbouring countries; one genus, Forsteronia, is found in tropical America.

The rubber furnished by many of these vines is of excellent quality, and if carefully prepared it will realise high prices.

Numerous attempts have been made to cultivate rubber vines in suitable localities, but the results obtained compare very unfavourably with those given by rubber trees. The vines do not, as a rule, stand transplanting well, they are of comparatively slow growth, and their climbing stems are not so suitable for tapping as the trunk of a tree. The yield of rubber obtained from the vines is also much less than that furnished by the best rubber trees. For these reasons the cultivation of the vines is being abandoned in favour of suitable trees.

African Rubber Vines.—These belong to the four genera Landolphia, Clitandra, Carpodinus, and Cryptostegia. They occur right across the continent from Senegambia to Abyssinia in the north to Rhodesia and Zululand in the south. The principal vines with their distributions are as follows:—*Landolphia Heudelotii* (Senegambia to Sierra Leone); *Landolphia owariensis* (Sierra Leone to the Bahr-el-Ghazal and southwards into the Congo State); *Landolphia Kirkii* (the whole of the east coast from Abyssinia to Zululand); *Landolphia Klainii* (Congo State and West Africa); *Landolphia Dawei* (Uganda); *Clitandra elastica* (Southern Nigeria); *Clitandra orientalis* (Uganda); *Landolphia* spp., and *Cryptostegia* spp. (Madagascar).

Practically the whole of the rubber obtained from these vines is collected by the natives from wild plants. Several methods of preparation are practised. In the case of some of the vines the latex exudes slowly when incisions are made in the bark and coagulates in the cuts forming strips of rubber, which are afterwards pulled off and wound into balls. The latex of other vines flows more freely so that it can be collected in bulk and subsequently coagulated by heating or by the addition of an acid juice or infusion, the resulting rubber being then made up into various forms. Sometimes the vine is severed near the base and cut into lengths, which are placed upright in a trough in order that the latex may drain out. Another method is to dry the stems, strip off the bark, and then to separate the rubber from the latter by a process of macerating in hot water and beating. This method is largely employed for obtaining the so-called root rubber from the rhizomes of the shrubby forms of Landolphia and Clitandra, such as *L. Thollonii* and *C. henriquesiana*. Machines for carrying out this treatment have been devised, and are now being employed on a commercial scale in several countries.

Asiatic Rubber Vines.—In Asia rubber-yielding vines occur principally in Lower Burma, Indo-China, the Malay Peninsula and Archipelago, and also in India. They include species of Urceola, Willughbeia, Parameria, Ecdysanthera, Chonemorpha, Rhyncodia, and Cryptostegia. The collection of the rubber from these plants is entirely in the hands of the natives, and owing to the crude methods employed the product is often of inferior quality.

American Rubber Vines.—This group of rubber plants is represented in tropical America by two species of Forsteronia, *F. floribunda* and *F. gracilis*, which occur in Central and South America and in the West Indies.

The results of the examination of a large number of specimens of vine rubber are recorded in the following section.

AFRICAN VINE RUBBERS.

SIERRA LEONE.

I.—*Jenje Rubber* (1906).

The vine which yields this rubber is known by the natives as Poré, and appears to be a species of *Landolphia*, closely related to *L. owariensis*, Beauv., though its identity cannot be definitely determined from the specimens submitted. It may be noted in this connection that Mr. Scott Elliott brought back from Sierra Leone a sample of "Djenge" rubber, and the corresponding botanical specimens were identified as *Landolphia Heudelotii*, A. DC., var. *Djenge*, Stapf. Further specimens of the Poré vine will consequently be required before its identity can be definitely established.

The sample of Jenje rubber consisted of a large ball which weighed about 12 oz. and had been formed by the aggregation of fairly thick strips. The rubber was dark brown, slightly sticky in places, and fairly free from vegetable impurity; it exhibited very good elasticity and tenacity.

The chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·2	—
Caoutchouc	85·8	88·6
Resin	5·8	6·0
Proteid	2·0	2·1
Insoluble matter ...	3·2	3·3
Ash	1·98	2·04

These figures show that the sample is of good quality, there being 88·6 per cent. of true rubber in the dry material, whilst, on the other hand, the percentages of resin and proteid are low.

The sample was submitted to brokers, who valued it at about 3*s*. 9*d*. per lb. in London, when fine hard Para was selling at 5*s*. 5½*d*. per lb.

II.—*Njawa Rubber* (1906).

The plant yielding this rubber is described as a vine, known as Sagba, but its botanical identity remains uncertain.

The sample of rubber, weighing about 8 oz., consisted of a thick cake which was purplish-black externally but whitish within when freshly cut; it was almost free from vegetable impurity, but possessed a very unpleasant odour. The rubber was rather deficient in both elasticity and tenacity, elongating a little and ultimately tearing when stretched.

The chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·6	—
Caoutchouc	71·1	73·8
Resin	21·3	22·1
Proteid	2·9	3·0
Insoluble matter ...	1·1	1·1
Ash	0·41	0·42

These figures show that the rubber is of very resinous character, 22 per cent. of this constituent being present in the dry material. The composition as shown by the analysis fully accounts for the deficiency in elasticity and tenacity.

The sample was valued by brokers at about 3*s*. 3*d*. per lb. in London, with fine hard Para at 5*s*. 5½*d*. per lb.

III.—*Landolphia Rubber* (1906).

A number of small samples of specially prepared Landolphia rubber were received for comparative examination.

Eight of the specimens, Nos. 1 to 8, were in the form of small biscuits, varying from 2 to 7 inches in diameter, and some of them not more than $\frac{1}{32}$ inch in thickness. The rubber was clean, well-prepared, of brown colour, translucent, and had a distinct smoky odour; it exhibited very good elasticity and tenacity.

Sample No. 9 was in the form of thin strips of reddish-brown rubber, which exhibited good physical properties.

Sample No. 10 consisted of small balls of rubber about 1 inch in diameter prepared by the native method. The balls were dark coloured, rather sticky on the surface, and contained a fair amount of vegetable impurity. The rubber was strong and elastic.

For the purpose of analysis No. 7 was chosen as representative of the "biscuit" rubber, and the figures obtained for it, together with those of Nos. 9 and 10, are given in the following table:—

	No. 7.	No. 9.	No. 10.
	Per cent.	Per cent.	Per cent.
Moisture	1·8	1·8	5·2
Caoutchouc	85·2	85·2	75·9
Resin	11·8	11·6	9·5
Proteid...	0·8	1·0	1·6
Insoluble matter	Nil	Nil	6·2
Ash	0·4	0·4	1·6

These results indicate that samples Nos. 7 and 9 are of good quality and almost identical in composition. They contain over 85 per cent. of caoutchouc and only a small percentage of proteid; the amount of resin, however, is a little high. The balls prepared in native fashion (No. 10) contain a fair amount of insoluble impurity, and whilst the percentage of proteid is higher than in the other samples the quantity of resin is lower.

The samples were submitted for valuation with the following results:—

The eight samples of biscuit rubber (Nos. 1 to 8) and the strips (No. 9) were stated to be very satisfactory both in preparation and appearance, and were valued at the same price, viz., 5*s.* per lb., with fine hard Para from South América quoted at 5*s.* 10*d.* per lb. The balls (sample No. 10) were valued at 3*s.* 6*d.* per lb. on the same date.

It is evident from these results that the Landolphia rubber in "biscuits" or "strips" will realise a much higher price than the same rubber prepared in balls by the native method.

IV.—*Landolphia rubber prepared in strips by the natives* (1907).

The sample weighed 15 oz., and consisted of 15 flat strips of rubber about 1 foot in length and from 1 to 1½ inch in width. The rubber was clean, dark coloured, and had a smoky odour; its physical properties were very satisfactory.

The rubber had the following composition:—

	Per cent.
Moisture	2·8
Caoutchouc	83·5
Resin	9·5
Proteid	1·7
Insoluble matter	2·5
Ash	0·73

The sample was valued at 3*s.* 6*d.* to 3*s.* 9*d.* per lb., with fine hard Para at 4*s.* 7*d.* per lb.

The rubber compares favourably in composition with the specially prepared specimen (No. 9) described above, but its darker colour and rougher appearance reduce its value.

V.—*Landolphia Rubber from the Karene District* (1907).

This sample weighed 2½ lb., and consisted of small balls of dark brown rubber, which were slightly sticky both externally and internally and contained a fair amount of vegetable impurity.

The composition of the rubber was as follows:—

	Per cent.
Moisture	2·2
Caoutchouc	80·6
Resin	6·5
Proteid	1·4
Insoluble matter	9·3
Ash	0·98

The sample was valued at 3*s.* 4*d.* to 3*s.* 6*d.* per lb., with fine hard Para quoted at 4*s.* 7*d.* per lb.

This rubber is of good quality, but contains a large amount of vegetable impurity, which could be considerably reduced by the exercise of more care on the part of the natives during collection.

VI.—*Rubber of* Landolphia owariensis, *var. nr.* Jenje (1908).

The sample consisted of three sheets of rubber and one small ball, which together weighed 6 oz. The rubber had apparently been smoked, and varied in colour from brown to black; it exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Per cent.
Moisture	5·4
Caoutchouc	84·8
Resin	8·5
Proteid	1·0
Insoluble matter	0·3
Ash	0·42

The sample was valued at 3*s*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

This rubber is of good quality, and consignments of similar character would be readily saleable.

VII.—*Rubber of* Landolphia *sp.* (1908).

The sample weighed 3 oz., and consisted of one small piece and one small ball of black rubber. The rubber was clean, and exhibited good elasticity and tenacity.

The rubber had the following composition:—

	Per cent.
Moisture	8·2
Caoutchouc	76·2
Resin	7·4
Proteid	5·3
Insoluble matter	2·9
Ash	1·85

The sample was valued at about 3*s*. per lb. in this country, with fine hard Para quoted at 3*s*. 5½*d*. per lb.

The rubber is of good quality, but not quite equal in composition to the preceding specimen, No. VI.

VIII.—*Vine Rubbers from the Gola Forest* (1907).

A number of samples of rubber obtained by Captain H. H. Bond during a patrol of the portion of the Gola Forest adjacent to the Liberian Frontier, were forwarded for examination to the Imperial Institute by the Colonial Office. It is reported that portions of the Gola Forest are very rich in rubber-yielding vines, but no information is available regarding the botanical identity of the plants. The results of the examination of the rubbers will, however, be of interest. With the exception of Sample No. 4, which contained a large percentage of resin, the rubbers are of very promising quality, and there is no doubt that, if carefully collected and prepared, they would command satisfactory prices in the market.

No. 1. Rubber from Forest near Manina.

The sample was a thick sausage-shaped piece of rubber, weighing 5 oz.; it was dark-coloured externally, but pinkish-white and moist within when freshly cut. The rubber was strong and fairly clean.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	10·3	
Caoutchouc	66·7	74·4
Resin	11·8	13·1
Proteid	5·4	6·0
Insoluble matter ...	5·8	6·5
Ash	2·25	2·51

The specimen was valued by brokers at 4*s*. per lb. in London. For comparison with this and the following valuations it may be stated that the current value of fine hard Para from South America was 5*s*. 2*d*. per lb.

This rubber is of very fair quality, although the percentages of resin and proteid are rather high. It exhibited very good physical characters, and there is no doubt that it could be improved by careful collection and preparation.

No. 2. Rubber from Bandi country.

A thick sausage-shaped piece of rubber, weighing about 12 oz.; it was dark-coloured externally, but whitish and very moist within when freshly cut. The rubber was sticky, and contained much impurity in the form of fragments of bark.

A chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	20·1	—
Caoutchouc	67·4	84·3
Resin	4·5	5·6
Proteid	0·9	1·1
Insoluble matter ...	7·1	9·0
Ash	0·89	1·11

The sample was valued at 2*s*. to 2*s*. 3*d*. per lb. in London.

This rubber is satisfactory so far as chemical composition is concerned, the percentages of resin and proteid being low. It had, however, been badly prepared, and on account of its stickiness would only fetch a low price. Careful preparation would remedy this defect, and would also reduce the rather large amount of insoluble impurity present in this sample.

No. 3. Rubber from Gola Forest near Bobabu.

The sample consisted of three pieces of rubber, of irregular shape, formed by the aggregation of thick strips. The rubber was light-coloured, strong and clean.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	11·3	—
Caoutchouc	77·6	87·4
Resin	5·3	6·0
Proteid	1·4	1·6
Insoluble matter ...	4·4	5·0
Ash	1·57	1·77

The specimen was valued at 4*s*. per lb. in London.

This rubber is of very good quality, and would meet with a ready sale at satisfactory prices.

No. 4. Rubber from Gola Forest on left bank of Morro River.

A thick lump of rubber, weighing about 6 oz., dark-coloured on the surface, but lighter within and moist; it possessed a disagreeable odour. The rubber was weak and slightly sticky, but contained very little vegetable impurity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	14·2	—
Caoutchouc	62·0	72·2
Resin	21·3	24·8
Proteid	1·0	1·2
Insoluble matter ...	1·5	1·8
Ash	0·57	0·66

The sample was valued at 3*s*. per lb. in London.

This rubber is of poor quality on account of the large amount of resin present. This defect may possibly have arisen through admixture with inferior latex, and if so it could be remedied by greater care in collection.

No. 5. Rubber from Tunkia Forest.

Two pieces of rubber of irregular shape, dark-coloured externally, but white within when freshly cut; a fair amount of vegetable impurity was present. The physical properties of the rubber were very satisfactory.

A chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·4	—
Caoutchouc	81·5	85·2
Resin	5·0	5·2
Proteid	1·1	1·2
Insoluble matter ...	8·0	8·4
Ash	1·16	1·21

The sample was valued at 4*s*. per lb. in London.

This rubber is of very good quality, and would be readily saleable. Careful collection would eliminate the greater part of the vegetable impurity in the sample.

Gold Coast.

I.—"*Krepi Ball*" *Rubber*, Landolphia owariensis, *Beauv.* (1906).

This sample of rubber was collected in Larteh and consisted of three small balls, together weighing 3¼ oz. The rubber was brown, and contained a small amount of impurity in the form of fragments of bark; it exhibited very good physical properties, being strong and very elastic.

The following results were obtained on analysis:—

	Per cent.
Moisture	1·0
Caoutchouc	91·3
Resin	4·7
Proteid	0·9
Insoluble matter	2·1
Ash	0·42

It is evident from these figures that this rubber is of very good quality, over 90 per cent. of caoutchouc being present. The percentages of resin and proteid are low, the amount of the latter constituent being exceptionally small.

The brokers described the rubber as clean, dark ball, and valued it at 4*s.* 3*d.* to 4*s.* 6*d.* per lb. in London, with fine hard Para quoted at 5*s.* 4*d.* per lb.

II.—"*Pempeneh*" *Rubber*, Landolphia owariensis, *Beauv.*, *from the Northern Territories* (1908).

The sample was labelled as follows:—"Sample of rubber collected in the Northern Territories of the Gold Coast. Native name: 'Pempeneh.'" It consisted of two thin "biscuits" and one small ball, together weighing 3 oz. The biscuits were brown, clean and slightly sticky; the ball was very soft, and moist internally. The rubber exhibited good physical properties, being strong and elastic.

An analysis of the biscuits gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·8	—
Caoutchouc	86·3	90·6
Resin	5·9	6·2
Proteid	0·8	0·9
Ash	2·2	2·3

The biscuits were valued at 3*s.* to 3*s.* 3*d.* per lb. in this country, with fine hard Para from South America quoted at 3*s.* 5½*d.* per lb.

This rubber is of good quality and consignments of similar quality would always be readily saleable.

Southern Nigeria.

I.—*Rubber of* Landolphia *sp. or* Carpodinus *sp.* (1903).

The specimen consisted of a small lump of brown rubber which contained a considerable amount of impurity in the form of fragments of bark and sand. The rubber was very porous and exhibited fair elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·4	—
Caoutchouc	58·4	59·1
Resin	4·4	4·5
Insoluble matter ...	35·8	36·4
Ash (chiefly sand) ...	27·1	27·5

Apart from the large amount of sand included with the rubber, probably owing to the method of collection employed, the composition of the sample shows it to be of very fair quality. The percentage of resin is low.

II.—*Niger Root Rubber* (1903).

The sample was a small block of rubber weighing about 3 oz. When received it was a light reddish-brown colour externally, but on exposure to the air it rapidly darkened and became almost black. Internally it was light reddish-brown, very porous, and contained a considerable amount of moisture and some vegetable impurity.

It had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	24·6	—
Caoutchouc	63·4	84·1
Resin	3·6	4·7
Insoluble matter ...	8·4	11·2
Ash	3·7	4·8

The percentage of resin present is only low, but the amounts of moisture and insoluble impurity are excessive.

III.—"*Ubabikpan*" *Rubber*, Clitandra elastica (1908).

The specimen, which weighed $5\frac{3}{4}$ lb., bore the following label:—"'Ubabikpan' rubber from *Clitandra elastica*."

It consisted of 18 biscuits of rubber ranging from 3 to 6 inches in diameter, and from $\frac{3}{8}$ to $1\frac{1}{4}$ inch in thickness. The biscuits, which were covered with mould on arrival, varied from brown to black externally, and many of them were white and moist within when freshly cut. The rubber was free from stickiness, and exhibited good elasticity and tenacity.

The percentage composition of the rubber was found to be as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	5·2	—
Caoutchouc	85·7	90·4
Resin	3·8	4·0
Proteid	3·0	3·2
Insoluble matter ...	2·3	2·4
Ash	0·40	0·42

The rubber was valued at 2*s.* 8*d.* to 2*s.* 10*d.* per lb. in this country, with fine hard Para quoted at 3*s.* $5\frac{1}{2}$*d.* per lb.

The results of the chemical examination are very satisfactory, the percentages of resin and proteid being low. The rubber would be improved in quality if the biscuits were made thinner and were more thoroughly dried.

IV.—*Rubber of the* "*Marodi*" *Vine* (1908).

The specimen was labelled "Rubber from 'Marodi.' A. H. Unwin, No. 269"; and weighed $5\frac{3}{4}$ oz. It was a thick, rough biscuit of brown rubber, about 6 inches in diameter, and from $\frac{3}{8}$ to $\frac{1}{2}$ inch thick. The rubber was dry, well prepared, and exhibited very satisfactory physical properties.

A chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·4	—
Caoutchouc	78·8	80·8
Resin	5·2	5·3
Proteid	9·3	9·5
Insoluble matter ...	4·3	4·4
Ash	0·63	0·69

The sample was valued at 2*s.* 6*d.* per lb. in this country with fine hard Para from South America quoted at 3*s.* 1*d.* per lb.

This "Marodi" rubber is of very fair quality, and consignments of similar character would be readily saleable. The percentage of proteid is rather high, and the amount of caoutchouc is correspondingly reduced.

V.—*Landolphia Rubber prepared in the Eastern Province* (1910).

Twelve small cylindrical pieces of light brown rubber, sticky externally and moist and white within. The rubber exhibited very good physical properties.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	7·9	—
Caoutchouc	86·7	94·2
Resin	1·5	1·6
Proteid	1·5	1·6
Insoluble matter ...	2·4	2·6
Ash	0·1	0·1

The rubber was valued at about 7*s*. per lb. in London, with fine hard Para at 10*s*. per lb.

This rubber is of very satisfactory composition, containing very low percentages of resin and proteid. Its botanical source is not known with certainty, but it is believed to have been derived from a species of Landolphia.

NORTHERN NIGERIA.

"*Flake*" *Rubber from* Carpodinus hirsuta, *Ilua* (1906).

The sample was forwarded in a bottle containing water which had a strong putrescent odour. The material was of very pale colour and exhibited little elasticity or tenacity.

An analysis showed it to have the following composition:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	25·0	—
Caoutchouc	7·1	9·4
Resin	66·6	88·8
Proteid	0·9	1·2
Ash	0·4	0·5

It will be seen from these figures that this rubber is of very inferior quality, containing 88·8 per cent. of resin and only 9·4 per cent. of caoutchouc in the dry material. It realises only a low price in the market.

SENEGAL (1906).

This sample of rubber, collected and prepared at the Rubber School of Banfora, Upper Senegal-Niger, was forwarded to the Foreign Office by Captain Cromie, His Majesty's Consul-General at Dakar, in connexion with his report upon the trade, agriculture, &c., of French West Africa for the years 1904-5 (Diplomatic and Consular Reports, No. 3543, Annual Series). The rubber was transmitted to the Imperial Institute by the Foreign Office, and it was thought that it would be of interest to submit the sample to chemical examination and commercial valuation.

The results of the investigation are given in the following report:—

The sample weighed 4¼ oz., and consisted of a thin sheet of rubber. This had been folded twice, and as the surfaces in contact had become firmly adherent, a cake of about three-eighths of an inch in thickness had been produced.

The rubber had been very well prepared; it was light brown, free from impurity, and possessed excellent physical properties.

On analysis the rubber was found to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	11·7	—
Caoutchouc	82·8	93·8
Resin	5·2	5·9
Proteid	0·1	0·1
Ash	0·2	0·2

These results show that the composition of the rubber is exceedingly satisfactory. The dry material contains nearly 94 per cent. of true rubber and less than 6 per cent. of resin, whilst proteid is practically absent and the percentage of ash is low.

The rubber was submitted to brokers who described it as fine clean sheet which would sell well at about 4*s*. 6*d*. per lb., with fine hard Para from South America quoted at 5*s*. 2*d*. per lb.

It is evident from the results of the investigation that this rubber is well prepared and of good quality. No information was supplied regarding the botanical source of the rubber, but it is probable that it was prepared from *Landolphia Heudelotii*.

French Congo.

"*Root*" *Rubber of* Landolphia Thollonii, *Dewèvre* (1903).

The sample consisted of a small piece of rubber, black externally, but greyish-white within. The physical properties of the rubber were satisfactory.

An analysis showed it to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	19·2	—
Caoutchouc	75·0	92·8
Resin	4·5	5·6
Insoluble matter ...	1·3	1·6
Ash	1·20	1·48

The rubber was therefore of good quality so far as chemical composition is concerned. It was valued by brokers as worth about 2*s*. 10*d*. per lb. in London with fine hard Para at 4*s*. per lb.

East Africa Protectorate.

I.—*Rubbers and Rubber-yielding Vines from Nandi and Takaungu* (1903).

These specimens were forwarded to the Imperial Institute from the East Africa Protectorate, with a view to the chemical examination and commercial valuation of the rubber, and the botanical identification of the plants from which the rubber was obtained. They comprised:—

1. The leaves, flowers, fruit and coagulated latex of a vine which grows in abundance in the Nandi Forest. Forwarded by Mr. Mayes.
2. Rubber from Nandi. Forwarded by Mr. Hobley.
3. Rubber from Takaungu.
4. Three rubber vines from Takaungu, labelled "Mbungu," "Vipo" and "Impira" respectively.

The botanical specimens have been identified at Kew by Dr. Otto Stapf, who reports that the vine from the Nandi Forest is *Landolphia watsoniana*, Voigtherr; the vines from Takaungu, labelled Mbungu and Vipo, prove to be the same species, viz., *Landolphia Petersiana*, Dyer; and the vine from Takaungu, labelled Impira (also known as M'pira) is *Landolphia Kirkii*, Dyer.

Of the three samples of rubber accompanying the botanical specimens, two were forwarded from Nandi, one of these being derived from the vine which has been identified as *Landolphia watsoniana*, whilst the botanical source of the other is not stated. In the case of the sample of rubber from Takaungu, no indication is given as to the particular plant from which it was obtained.

Description of Specimens.

No. 1. Rubber from Nandi, forwarded by Mr. Mayes. Derived from *Landolphia watsoniana*.

This was a small ball of rubber, about $1\frac{1}{2}$ inches in diameter, rather sticky and dark brown externally; the rubber in the centre of the ball was pinkish-white, but turned brown on exposure to the air, and was not so sticky as the outside surface; small particles of vegetable matter were present. The rubber was fairly elastic and tenacious.

No. 2. Rubber from Nandi, forwarded by Mr. Hobley.

A small ball of rubber, almost exactly resembling No. 1 in appearance and properties, the only differences being that it contained more moisture and the freshly-cut surface was much whiter.

No. 3. Rubber from Takaungu.

A ball of rubber about $2\frac{1}{2}$ inches in diameter, brown in colour externally and slightly sticky; the freshly-cut surface showed a mottled appearance, varying from white to light brown in colour, and was not sticky; the ball was slightly porous, and contained small particles of vegetable matter distributed through it. The rubber was very elastic and tenacious.

Results of Examination.

The results of the chemical examination of the specimens were as follows:—

—	Moisture.	Caoutchouc.	Resin.	Insoluble matter.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
No. 1. Rubber from Nandi forwarded by Mr. Mayes.	12·9	67·2	11·9	8·0	1·3
No. 2. Rubber from Nandi forwarded by Mr. Hobley.	20·8	61·9	9·7	7·6	1·3
No. 3. Rubber from Takaungu	5·7	84·2	5·0	5·1	4·0

These results indicate that so far as chemical composition is concerned the rubber from Takaungu is of very good quality, since it contains a low percentage of moisture and resin and 84 per cent. of true caoutchouc, being much superior in these respects to the samples from Nandi, in which the percentage of resin is much higher. The two rubbers from Nandi are, as already pointed out, almost identical in appearance, and also agree very closely in composition, as is seen on comparing the following figures calculated for the dry material:—

—	Caoutchouc.	Resin.	Insoluble matter.
	Per cent.	Per cent.	Per cent.
No. 1	77·1	13·6	9·3
No. 2	78·2	12·2	9·6

It would seem probable, therefore, that the two specimens were derived from the same, or very closely allied, species of plant.

Commercial Value.

Samples of the rubbers, together with the results of the chemical examination, were submitted to brokers for commercial valuation. They reported that the specimen from Takaungu, which they described as nice, hard, red rubber, would sell well at about 2*s*. 6*d*. to 2*s*. 7*d*. per lb., *ex* warehouse in London, if not sticky. The samples from Nandi were described as a rather softer rubber, Nyasa character, and dark coated, which, if not heated, would be worth about 2*s*. 3*d*. to 2*s*. 4*d*. per lb. The brokers added that all the samples appeared to have been externally heated, but suggested that this may possibly have occurred during transit, and that larger consignments might

not show this defect. The current price of fine hard Para on the date of the above valuation was 3*s.* 3½*d.* per lb.

It is clear from the above report that consignments of rubber of similar quality to these samples could be easily disposed of in the London market.

II.—*Rubber from Wadruma Forest, Shimba Hills* (1903).

This sample of rubber was stated to have been obtained from a climbing plant growing in the Shimba Hills near Mombasa. The label upon the specimen furnished the additional statement that the rubber was obtained from the Wadruma Forest, two hours' journey from Muele Hill, Shimba.

It consisted of a ball of rubber, about 3 inches in diameter, light brown externally, and slightly sticky; the freshly-cut surface showed a mottled appearance, varying in colour from white to light brown, and was less sticky than the outer surface; the ball was slightly porous, and contained small particles of vegetable matter distributed through it. The rubber was very elastic and tenacious.

In appearance the specimen closely resembled the rubber forwarded from Takaungu, which is dealt with in the preceding report.

The analytical results were as follows:—

	Per cent.
Moisture	4·2
Caoutchouc	87·7
Resin	4·2
Insoluble matter	3·9
Ash	2·5

These figures are very similar to those obtained for the Takaungu rubber, and prove that the sample is of good quality.

A specimen of the rubber, together with the results of the chemical examination, was submitted to brokers for commercial valuation, and was classed by them (together with the sample from Takaungu) as nice, hard, red rubber, which would sell well, if not sticky, at 2*s.* 6*d.* to 2*s.* 7*d.* per lb., *ex* warehouse in London, with fine hard Para at 3*s.* 3½*d.* per lb.

III.—*Rubbers and Rubber-vines from Takaungu* (1904).

The specimens from Takaungu previously examined (see p. 367) included three rubber-vines named "Mbungu," "Vipo," and "Impira" respectively, but these were accompanied by only one sample of rubber. The "Mbungu" and "Vipo" vines were identified at Kew as *Landolphia Petersiana*, whilst that known as "Impira" proved to be *Landolphia Kirkii.* No information was however supplied as to the botanical origin of the rubber.

The specimens now under notice were stated to represent the vine which occurs in considerable quantities near Takaungu,

and the rubber which it furnishes. Three large specimens of the stems, leaves and fruits of the vine, and also a number of the flowering shoots, were forwarded for examination, together with two samples of rubber.

The botanical specimens were referred for identification to the Director of the Royal Botanic Gardens, Kew, who reported that they all belonged to the same species of Landolphia, viz., *Landolphia Kirkii*. The plant is therefore identical with the "Impira" vine previously forwarded, but no vernacular name was mentioned in the present case.

The two samples of rubber were labelled "Sokoki" and "M'toni" respectively, and it is presumed that both of them were the product of *Landolphia Kirkii*, Dyer.

"Sokoki" Rubber.

The specimen consisted of five balls of rubber, each about 2½ inches in diameter, and together weighing 1 lb. 10 oz. They were light-brown externally, but creamy-white and slightly moist within, and contained only a small amount of foreign vegetable matter. The rubber was not sticky, and exhibited very good physical properties.

"M'toni" Rubber.

This sample consisted of six balls, together weighing 2¼ lb., which were almost identical in appearance and character with the preceding specimen. The only noticeable difference was that the "M'toni" rubber contained a considerable amount of foreign matter in the form of sand, which was chiefly present in the external layers, and had evidently been included with the rubber during collection.

The chemical examination of the two rubbers gave the following results, the sample of the "M'toni" rubber being selected so as to represent its average composition.

—	"Sokoki" rubber.		"M'toni" rubber.	
	Rubber as received.	Composition of dry rubber.	Rubber as received.	Composition of dry rubber.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	11·7	—	9·1	—
Caoutchouc ...	78·9	89·4	78·2	86·1
Resin	6·8	7·7	4·1	4·5
Insoluble matter...	2·6	2·9	8·6	9·4
Ash	0·87	0·98	8·5	9·3

These results show that so far as chemical composition is concerned both samples are of good quality. The dry "Sokoki" rubber contained nearly 90 per cent. of caoutchouc and 7·7 per cent. of resin, whilst the "M'toni" rubber would have given

even better figures than these had it not contained such a large amount of sand. Great care should be exercised in the collection of rubber in order to avoid the inclusion of foreign matter, either vegetable or mineral, as the presence of considerable amounts of such impurities, as in the "M'toni" rubber, would diminish the value of commercial consignments.

The two rubbers were submitted to brokers for commercial valuation, the sample of "M'toni" rubber selected for this purpose being nearly free from sand in order that the quotation might represent the value of a properly-prepared specimen. The brokers reported that they considered both samples to be worth from 3*s*. 2*d*. to 3*s*. 3*d*. per lb. in the London market, with fine Para quoted at 4*s*. 3*d*. per lb.

IV.—*Rubber and Rubber-vine from the Kamasia Hills, Naivasha Province* (1904).

Botanical specimens of the leaves and fruits of a rubber-vine growing in the Kamasia Hills and also a very small sample of the rubber obtained from it were forwarded to the Imperial Institute for examination.

The leaves and fruits were identified at Kew as belonging to *Landolphia Kirkii*, Dyer, and the vine is therefore identical with that forwarded from Takaungu.

The sample of rubber consisted of eight small pieces, the total weight of which was only about 1 oz. The rubber was dark reddish-brown externally, but lighter in colour and slightly moist within, and contained a fair amount of foreign vegetable matter. It was not sticky, and exhibited fair elasticity and great tenacity.

The chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	10·8	—
Caoutchouc	68·3	76·6
Resin	11·5	12·8
Insoluble matter ...	9·4	10·6
Ash	1·05	1·17

Although this rubber was derived from the same species of vine as the specimens from Takaungu, the analysis shows that it is not of such good quality as these, owing to the much higher percentage of resin present. Like the "M'toni" rubber, it contained a considerable amount of impurity, which in this case consisted of fragments of wood and bark.

The specimen was, however, scarcely large enough to be fully representative. If properly prepared the rubber would probably be of equal value to the specimens obtained from the same species of vine growing near Takaungu.

V.—*Rubber and Rubber-vine from Rabai* (1904).

This sample of rubber was accompanied by a specimen of the leaves and immature fruits of the vine from which it was obtained. It was evident that the plant was a species of Landolphia, but it could not be completely identified from the specimen supplied.

The rubber consisted of a single ball, nearly four inches in diameter and weighing 13 oz. The ball appeared to have been formed by an aggregation of shreds of rubber, and was of a uniform light-brown colour externally, but lighter within, being almost white at the centre; it was rather porous and contained an appreciable amount of foreign vegetable matter. The rubber was not sticky and exhibited very good physical properties.

The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·3	—
Caoutchouc	84·1	87·9
Resin	4·5	4·7
Insoluble matter ...	7·1	7·4
Ash	3·62	3·78

The rubber is therefore of good quality, the percentage of resin being low, but the amount of vegetable matter included might be considerably reduced by more careful collection.

The brokers to whom the rubber was submitted valued it at 3*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 3*d*. per lb.

VI.—*Rubber of* Landolphia *sp.* (1904).

This sample of rubber was stated to have been prepared from a species of Landolphia. It consisted of a single ball of rubber measuring about 3½ inches in diameter and weighing 10 oz. The ball was dark-coloured throughout, and when cut open was found to consist of an inner ball, about 3 inches in diameter, enclosed in a cover which could be easily separated. The rubber forming this outer cover was very sticky, probably owing to changes which had occurred during transit, but the inner ball had not been so much affected. The rubber was very porous, and contained a considerable quantity of acid liquor; it was soft and rather spongy, but was satisfactory in elasticity and tenacity.

The analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	17·8	—
Caoutchouc	67·7	82·5
Resin	11·1	13·4
Insoluble matter ...	3·4	4·1
Ash	1·2	1·5

The rubber is therefore of very fair quality, containing 82·5 per cent. of caoutchouc in the dry material, but the percentage of resin is higher than is desirable. In this latter respect it compares unfavourably with several of the preceding specimens of the rubber of *Landolphia Kirkii* from the East Africa Protectorate, which were found to contain less than 5 per cent. of resin.

A portion of the inner ball was submitted for valuation to commercial experts, who reported that it would be worth about 3*s.* per lb. in the London market, with fine hard Para rubber quoted at 4*s.* 10*d.* per lb. A rather higher price, up to 3*s.* 6*d.* per lb., would probably have been offered for the rubber if it had been better prepared, and free from the defects which this specimen exhibited.

VII.—*Rubber from the Sotik Forest* (1905).

This sample of rubber was stated to have been collected in the Sotik Forest, and was accompanied by a botanical specimen of the vine from which it was obtained. With the object of facilitating the botanical identification, the following description was furnished of the flowers of the plant:—"The corolla is dark red, inflated below the middle; the stamens are inserted above the widened part of the corolla tube."

The botanical specimen of the plant was transmitted to the Director of the Royal Botanic Gardens, Kew, for identification. He reported that the material was insufficient to permit of a satisfactory identification, but stated that the plant was a Landolphia, and that the flower closely resembled that of *Landolphia ugandensis*, Stapf. The previous specimens of vines forwarded from the East Africa Protectorate to the Imperial Institute have been identified as *Landolphia watsoniana*, *Landolphia Petersiana* and *Landolphia Kirkii* (*see* preceding reports).

The sample of rubber consisted of two balls, together weighing 1·9 oz. Externally the balls were black, but when cut they were found to be almost white internally, and to contain a considerable quantity of foreign vegetable matter. The rubber was somewhat soft, but exhibited good elasticity and tenacity, and was free from stickiness.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	6·2	—
Caoutchouc	78·3	83·5
Resin	9·1	9·7
Insoluble matter ...	6·4	6·8
Ash	2·4	2·5

These results show that so far as chemical composition is concerned this rubber is of good quality, since when dry it contains nearly 84 per cent. of caoutchouc. The amounts of resin and insoluble matter are rather high, but the percentage of the latter could be reduced by more careful collection and preparation.

The high percentage of resin may be characteristic of the rubber yielded by this plant, or it may be due to the present specimen having been collected from young vines. In the latter case it is probable that better rubber would be obtained from more mature vines.

The rubber was submitted for valuation to commercial experts, who were informed of the results of its chemical examination. They described it as "fair black-coated ball, rather wet, and slightly barky, worth about 3*s*. to 3*s*. 6*d*. per lb., and readily saleable," with fine hard Para at 5*s*. 2*d*. per lb.

VIII.—*Rubber from Lumbua* (1904).

This sample of rubber consisted of a single split ball weighing about 1½ oz. The ball was dark reddish-brown throughout, and contained small fragments of vegetable matter distributed through it. The physical properties of the rubber were very satisfactory, it being quite free from stickiness and exhibiting good elasticity and tenacity.

An analysis furnished the following results:—

	Per cent.
Moisture	2·7
Caoutchouc	82·2
Resin	9·3
Insoluble matter	5·8
Ash	2·1

This analysis shows that so far as chemical composition is concerned the rubber is of very fair quality, though the percentage of resin is rather higher than is desirable. The amount of resin present in the previous samples of rubber from the East Africa Protectorate has ranged from about 4 to 13 per cent., so that this Lumbua rubber occupies an intermediate position in this respect. No information was furnished regarding the botanical origin of this sample.

The sample was rather small for commercial valuation, as a quotation based upon a single ball may not represent the value of a large consignment of rubber derived from the same source. Rubber equal to the sample would fetch from 3*s*. 6*d*. to 3*s*. 9*d*. per lb. in London, with Para rubber quoted at 4*s*. 10*d*. per lb.

IX.—*Landolphia Rubber from Kericho* (1907).

This sample consisted of a small lump of rubber weighing about 3¼ oz. It was brown externally but white and moist within when freshly cut, and contained a small amount of vegetable impurity. The rubber exhibited good elasticity and tenacity.

The chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·3	—
Caoutchouc	74·7	82·3
Resin	10·5	11·6
Proteid	1·1	1·2
Insoluble matter ...	4·4	4·9
Ash	1·91	2·10

The rubber is therefore of very fair quality so far as chemical composition is concerned. The sample was rather small for trustworthy valuation, but consignments of similar quality would probably realise about 3*s.* 6*d.* per lb. in London, with fine hard Para quoted at 4*s.* 2*d.* per lb.

UGANDA.

1.—*Rubber of* Landolphia Dawei, *Stapf.* (1905).

This sample of rubber derived from *Landolphia Dawei*, Stapf, was forwarded to the Imperial Institute for exhibition purposes, but in view of the fact that no analysis of the rubber from this species of Landolphia had been recorded, it was considered desirable to submit the material to chemical examination. It was stated that the latex was collected in October, 1903, and underwent spontaneous coagulation in the bottle in which it was kept. The bottle remained corked until February, 1905, when the mass of rubber was removed, cut into cakes and pressed.

The sample consisted of three small cakes, about $\frac{1}{8}$ inch in thickness, and one narrow strip of rubber, which together weighed about 2 oz. The rubber was light-brown, opaque, free from visible impurity but marked with a few black spots. It possessed a slight stickiness but exhibited very good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·2	—
Caoutchouc	87·9	89·9
Resin	7·8	8·0
Insoluble matter ...	2·1	2·1
Ash	0·12	0·12

The results of the chemical examination prove that this rubber from *Landolphia Dawei* is of good quality, as the dry material contains nearly 90 per cent. of caoutchouc. The percentage of resin is a little higher than is frequently found in the best specimens of Landolphia rubber, which contain from 4·5 to 6 per cent. of this constituent, but the amount present is about the

average figure for this class of rubber. A number of analyses of samples derived from different vines will have to be made before the usual percentage of resin in the rubber of *Landolphia Dawei* can be definitely ascertained.

The sample, although rather small for commercial valuation, was submitted to brokers who reported that they considered the rubber to be worth at least 4*s*. per lb., perhaps more, especially if it were free from all traces of stickiness. For comparison with this valuation it may be stated that the current London price for fine hard Para from South America was 5*s*. 9*d*. per lb.

II.—*Rubber of* Landolphia Dawei (1906).

Three small samples of the rubber of this vine were forwarded for examination: (1) From the Budongo Forest, (2) from the Buddu Forest; and (3) from the West Ankole Forest. These all consisted of thin sheets of rubber, which were clean and of pale colour. The rubber was slightly sticky on the surface but exhibited very good elasticity and tenacity.

The results of the chemical examination were as follows:—

	Per cent.
Moisture	4·9
Caoutchouc	76·2
Resin	14·1
Proteid	2·0
Ash	2·8

The percentage of proteid is low, but, on the other hand, the amount of resin is high, amounting to 14·8 per cent. in the dry material, with the result that the percentage of caoutchouc is considerably reduced. This high percentage of resin is probably not a feature of the rubber of *Landolphia Dawei*, as the previous specimen contained only 8 per cent. of resin in the dry material. The amount of resin may possibly be found to depend on the age of the vine.

The rubber was valued at 5*s*. 9*d*. per lb in London, with fine hard Para rubber from South America quoted at 5*s*. 5*d*. per lb., and plantation Para biscuits at 6*s*. 3*d*. per lb.

III.—*Rubber of* Clitandra orientalis, *K. Schum.* (1906).

The specimen of rubber from this vine was collected in the Budongo Forest and consisted of a thin cake weighing a little over 2 oz. The rubber was dark brown, clean and free from stickiness; it was very strong and elastic.

The rubber was found to have the following composition:—

	Per cent.
Moisture	2·8
Caoutchouc	77·9
Resin	8·8
Proteid	9·4
Ash	1·1

In this case the percentage of proteid is distinctly higher than is

desirable and as the amount of resin is also a little high the proportion of true rubber present is correspondingly reduced.

The sample was valued by brokers at 5s 9d. per lb. in London, with fine hard Para quoted at 5s. 5d. per lb., and plantation Para biscuits at 6s. 3d. per lb.

SUDAN.

Rubber of Landolphia owariensis, *Beauv. var.* tomentella, *Stapf.*

I. (1903).

In continuation of a previous investigation at the Imperial Institute of this rubber from the Bahr-el-Ghazal a small consignment of about 100 lb., prepared by the natives, was forwarded for further examination and subsequent sale.

The rubber was made up in two forms, viz., balls and cylindrical rolls. The balls were about 1½ inches in diameter, and were dark reddish-brown externally but pinkish-white and slightly moist within; a small quantity of extraneous vegetable matter was present. The rubber was not sticky and exhibited very good elasticity and tenacity. The rolls were about 4 inches in length and 1 inch in diameter, and a number of them were attached together to form a small bundle. The rubber made up in this form was very similar in appearance and character to that sent in balls.

Samples of both balls and rolls were chemically examined with the following results:—

—	Rubber as received.		Composition of dry rubber.	
	Balls.	Rolls.	Balls.	Rolls.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	15·7	17·8	—	—
Caoutchouc	71·5	69·5	84·8	84·6
Resin	7·3	7·4	8·7	8·9
Insoluble matter ...	5·5	5·3	6·5	6·5
Ash	1·19	1·16	1·44	1·41

These figures showed that the balls and rolls were practically identical in composition, and that the rubber was of very fair quality, although the percentages of resin were higher than in the small samples which were first forwarded.

The consignment was subsequently sold in London at 3s. 5½d. per lb., the price of fine hard Para being 4s. 4d. per lb. at the time.

II. (1905).

These biscuits of Landolphia rubber from the Bahr-el-Ghazal were prepared experimentally in the manner adopted for the production of Para biscuits in Ceylon, viz., by pouring the diluted

latex into shallow vessels, adding a little acetic acid, and allowing it to stand until the rubber formed a cake which was removed, washed and dried.

The biscuits were pale, translucent, and quite free from foreign matter. The rubber was very satisfactory in physical properties.

An analysis of the dry rubber gave the following results:—

	Per cent.
Caoutchouc	94·1
Resin	5·7
Proteid	trace
Ash	0·18

The results showed that the rubber was of excellent quality, the amount of caoutchouc being over 94 per cent. The percentage of resin is low and compares favourably with the amount usually present in Landolphia rubber from other sources, whilst only a trace of proteid and very little ash are present. It is evident from the results of this analysis that the rubber of *Landolphia owariensis* var. *tomentella* is of excellent quality when carefully prepared.

This opinion regarding the quality of the biscuits was confirmed by brokers, who valued the rubber at 6*s* 6*d*. per lb. in London, with finest plantation Para biscuits at 7*s*. per lb., and fine hard Para at 5*s*. 7*d*. per lb.

III. (1906).

Twelve small samples of the rubber of *Landolphia owariensis* var. *tomentella*, which had been prepared experimentally in biscuit form in the Bahr-el-Ghazal, were forwarded for examination and valuation to the Imperial Institute.

It was stated that the rubber was collected in the months of September, October, and November—four specimens in each month—and from the figures given it appears that the largest yield of rubber per incision was obtained in November. The average yield of rubber from incisions of the same size was 0·61 gram, 0·77 gram, and 1·4 gram respectively in September, October, and November, whilst, according to figures supplied in a previous report, 0·79 gram per incision was obtained in August. These results appear to indicate an increased yield of rubber from the vines in November, but, in the absence of information regarding the condition of the different vines tapped, and whether the experiments were all made in the same locality, it would be unwise to draw any definite conclusions.

The rubber was in the form of thin biscuits varying in weight from 11·5 to 43·5 grams, the total being 298·5 grams. In appearance the samples could be divided into two groups according to colour, as some of the biscuits,—notably C, F, and G—were almost colourless, whereas the others varied from a very pale to a decided reddish-brown. The biscuits were well-prepared in all cases, and the physical characters of the rubber were excellent.

As the chemical composition of the rubber furnished by *Landolphia owariensis* var. *tomentella* in the Bahr-el-Ghazal had

been fully determined already it was not considered necessary to have these small specimens analysed, but they were submitted to brokers for valuation.

The brokers expressed a very high opinion of the appearance and physical properties of the rubber, in both which respects they stated that the samples compared very favourably with Para biscuits from Ceylon and the Federated Malay States. Judging by the appearance and the strength of the rubber, the brokers considered that consignments represented by samples A, B, D, E, H, J, K, and L would be worth 6*s.* 3*d.* to 6*s.* 4*d.* per lb. in London. This price was identical with the current value of Para biscuits prepared from cultivated trees. With reference to samples C, F, and G, they stated that consignments of similar character might realise even a little more, say 6*s.* 6*d.* per lb. on account of their freedom from colour.

It is clear from these results, which supplement previous investigations, that the rubber of *Landolphia owariensis* var. *tomentella*, when prepared in biscuit form, is of very good quality, and will command a high price in the market.

IV. (1906).

These samples of the rubber of *Landolphia owariensis* var. *tomentella* from the Bahr-el-Ghazal were forwarded to the Imperial Institute in order that their commercial value might be determined.

The samples comprised:—

(1) 1 lb. of rubber in thin biscuits.
(2) 3 lb. of rubber in cakes.
(3) $\frac{3}{4}$ lb. of scrap rubber.

Description of Samples.

(1) *Biscuits.*—These were very similar in appearance to the samples previously examined. They were divisible into two classes according to their colour, some being pale yellow, whereas others were light reddish-brown. The rubber was clean, well-prepared, and exhibited very good elasticity and tenacity.

(2) *Cakes.*—The cakes were larger and thicker than the biscuits, and also possessed a darker colour. The rubber was clean and well-prepared, although a slight tendency to surface stickiness was noticeable. The physical characters of the rubber were very good.

(3) *Scrap.*—The sample consisted of an aggregation of small pieces of rubber. It was dark coloured but clean, and exhibited very good elasticity and tenacity.

Results of Examination.

As samples of biscuit rubber from the Bahr-el-Ghazal had been already submitted to chemical examination, it was considered sufficient to determine the composition of the larger cakes. These gave the following results, for comparison with which the composition of the biscuits previously examined is added:—

	Present sample. Large cakes. Per cent.	Previous sample. Biscuits. Per cent.
Moisture	0·4	—
Caoutchouc	93·3	94·1
Resin	5·6	5·7
Proteid	0·4	trace
Ash	0·3	0·18

It will be seen from these figures that so far as composition is concerned the large cakes are practically identical with the biscuits. The rubber is of very good quality, containing a high percentage of caoutchouc and only small amounts of resin and proteid. The percentage of proteid in this rubber is exceptionally low.

Commercial Value.

The samples were submitted to experts and the following opinions and valuations obtained.

The biscuits were divided into two classes according to colour: (*a*) fine pale biscuits, strong and well-prepared, and (*b*) rather thicker and darker, also well-prepared. Both varieties were valued at the same price, viz., from 5*s*. to 5*s*. 3*d*. per lb. in London.

The larger cakes were described as "dark, glossy, thick and rather rough; good quality and fairly clean; strong, slightly inclined to be sticky." These were valued at 4*s*. 6*d*. per lb. in London.

The scrap rubber was classed as "small sausage and ball of Nyasa character," and was valued at 3*s*. 9*d*. per lb. in London.

For comparison with these valuations it may be stated that the current value in London of fine hard Para from South America was 5*s*. 1*d*. per lb., whilst Para rubber in biscuits from Ceylon and the Federated Malay States was quoted at 5*s*. 7*d*. per lb.

Conclusions.

The results of this investigation fully confirm the high opinion which has been expressed regarding the previous specimens of rubber from the Bahr-el-Ghazal. The valuation obtained for the present sample of biscuits compares very favourably with the current price of Para biscuits from Ceylon and the Federated Malay States. The lower quotation for the larger cakes of rubber was principally due to the slight surface stickiness which they showed. Great care should be taken to avoid this defect, which may have arisen through the exposure of the rubber to too high a temperature during drying or by over-heating during transit.

There is no doubt that if carefully prepared in biscuits or in the larger cakes the rubber would find a very ready sale and would realise good prices.

V. (1910).

A small consignment of rubber from the Bahr-el-Ghazal was forwarded recently to the Imperial Institute by the Sudan Govern-

ment for examination and subsequent sale. The rubber was derived from the indigenous rubber vine, *Landolphia owariensis*, var. *tomentella*, and it had been prepared in biscuits or sheets as recommended by the Imperial Institute in previous reports.

Description of Consignment.

The rubber biscuits and sheet varied in colour from pale to dark brown. Representative samples were retained for examination and exhibition at the Imperial Institute, and the remainder was sorted according to quality into 4 lots, which were classified by the brokers as follows:—

(1)	Rough, irregular biscuits, well-cured and in fairly good condition, strong and clean	150½ lb.
(2)	Similar to (1), but rather inferior	313 „
(3)	Pale biscuits, much better cured than (1) and (2), strong and in good condition ...	160½ „
(4)	Pressed sheet	23 „

The whole of the rubber was coated with powdered talc, which had no doubt been added to prevent the biscuits from adhering together.

Results of Examination.

A chemical analysis of representative samples of the dark and light biscuits gave the following results:—

—	Rubber as received.		Composition of dry rubber.	
	Dark.	Light.	Dark.	Light.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	0·4	0·3	—	—
Caoutchouc	93·2	92·4	93·6	92·7
Resin	4·4	5·6	4·4	5·6
Proteid	0·5	0·5	0·5	0·5
Ash	1·5	1·2	1·5	1·2

These figures show that so far as chemical composition is concerned the rubber is of very good quality, the two samples containing 92·7 and 93·6 per cent. of caoutchouc in the dry material. The amount of proteid is extremely low in both specimens, and it is noteworthy that the precentage of resin is higher in the light rubber than in the dark.

Commercial Value.

The consignment of rubber was sold in London at public auction and realised prices ranging from 6*s*. 9*d*. to 8*s*. 4*d*. per lb. The price of fine hard Para rubber on the day of the sale was 10*s*. 4*d*. per lb.

The brokers who sold the consignment reported that the rubber was exceptionally strong, and that with a little more care in pre-

paration, it should realise prices comparing favourably with those of Eastern plantation rubbers.

ABYSSINIA.

I.—*Rubber from Gidami* (1906).

The specimen weighed 6 oz. and consisted of a thick cake of rubber which was dark brown externally but whitish within when freshly cut. It was of soft, spongy character, and contained a considerable amount of moisture, but was almost free from vegetable impurities; it had a sour cheesy odour. The rubber was not sticky, and exhibited good elasticity and tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	21·5	—
Caoutchouc	59·5	75·9
Resin	15·9	20·2
Proteid	2·0	2·5
Insoluble matter ...	1·1	1·4
Ash	0·67	0·85

It will be seen from these results that the rubber contained a much higher percentage of resin than is desirable, and that it had been very imperfectly dried.

The rubber was valued at 2*s*. 6*d*. to 2*s*. 7*d*. per lb. in London, with fine hard Para at 5*s*. 5½*d*. per lb.

II.—*Rubber from Gidami* (1906).

The sample weighed about 7½ oz., and was labelled "Sudan Agency, Cairo, No. 15873 Commercial." It consisted of a thick circular cake of black rubber, which was rather moist. The rubber exhibited good elasticity and tenacity.

The chemical examination of the rubber furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	12·4	—
Caoutchouc	64·5	73·7
Resin	14·2	16·2
Proteid	1·0	1·1
Insoluble matter ...	7·9	9·0
Ash	1·13	1·29

A comparison of the figures expressing the composition of the dry rubber shows that this sample would have been much superior to the preceding specimen if it had not been for the large percentage of insoluble matter which it contained. The percentages of resin and proteid are both lower than in the previous sample, though the amount of resin is still higher than is desirable.

The rubber was described by brokers as "rough, dark-coated sheet," and was valued at 2*s*. 9*d*. to 3*s*. per lb. in London, with fine hard Para at 5*s*. 1½*d*. per lb.

III.—*Rubber from Sai-yu* (1906).

A small dark-coloured ball of rubber weighing only 1 oz.; it contained a considerable amount of vegetable impurity. The rubber was strong and free from stickiness.

The specimen was not sufficiently large for complete analysis, but the following determinations were made:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	9·3	—
Caoutchouc, Proteid	70·2	77·4
Resin	12·0	13·2
Insoluble matter ...	8·5	9·4
Ash	1·37	1·51

The percentage of resin in this rubber from Sai-yu is lower than in the specimens from Gidami, but it is still rather high, and the amount of insoluble impurity is excessive. The sample from Sai-yu was rather small for the purpose of valuation, but it was thought that consignments of the same quality would probably realise about 3*s*. 2*d*. per lb. in London, with fine hard Para at 5*s*. 5½*d*. per lb.

These rubbers from Abyssinia are of very fair quality, and if carefully prepared there is no doubt that they would be readily saleable. Care should be taken to exclude vegetable impurities as much as possible, and it would also be desirable to dry the rubber more thoroughly than was done in the case of the samples from Gidami.

NYASALAND.

Landolphia Rubber as collected and offered for sale by the natives (1904).

The sample weighed about 4 lb., and consisted of small hemispherical pieces, ranging up to 1¼ inches in diameter, which were evidently balls of rubber cut in two to facilitate drying. The external colour varied from light to dark reddish-brown, the flat surface usually presenting a mottled appearance, and some of the pieces showed a white moist centre when cut open. The rubber appeared to be of good quality; it was free from stickiness and exhibited good elasticity and tenacity. A small quantity of extraneous vegetable matter, chiefly pieces of bark, was present.

As some of the pieces were considerably darker than others, two separate samples were selected for analysis:—

A. Light coloured pieces.
B. Dark coloured pieces.

These gave the following results on analysis:—

—	Rubber as received.		Composition of dry rubber	
	A. Light.	B. Dark.	A. Light.	B. Dark.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	1·5	1·3	—	—
Caoutchouc	87·5	89·7	88·8	91·0
Resin	4·7	4·8	4·8	4·8
Insoluble matter ...	6·3	4·2	6·4	4·2
Ash	0·6	0·8	0·6	0·8

These results show that the light and dark coloured pieces are practically identical in composition and are of good quality, the percentage of resin being low.

Samples of the rubber were submitted for commercial valuation to brokers, who were informed of the results of the chemical examination. They described the rubber as good, clean ball, and valued it at 3*s*. 2*d*. to 3*s*. 3*d*. per lb. on the London market, with fine hard Para at 4*s*. 4½*d*. per lb.

NATAL.

I.—*Rubber of* Landolphia Kirkii, *Dyer, from Amatongaland* (1904).

Two samples of rubber prepared in Amatongaland from the "Ibungu" vine, *Landolphia Kirkii*, were forwarded to the Imperial Institute for analysis and valuation.

The specimens consisted of two half-balls of rubber which were identical in appearance and general characters. They bore no distinguishing marks, and were consequently denoted A and B to facilitate reference. The balls were light pinkish-brown externally, but were deep reddish-brown within. The rubber was quite dry, and only contained a small amount of foreign vegetable matter; it was not sticky, and exhibited very good elasticity and tenacity.

The chemical examination furnished the following results:—

—	Sample A.		Sample B.	
	Rubber as received.	Composition of dry rubber.	Rubber as received.	Composition of dry rubber.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	7·7	—	9·1	—
Caoutchouc	80·1	86·8	75·7	83·3
Resin	6·9	7·5	10·3	11·3
Insoluble matter	5·3	5·7	4·9	5·4
Ash	0·31	0·33	0·37	0·40

These analyses show that so far as chemical composition is concerned the rubbers are of good quality, especially sample A, which contains a very much lower percentage of resin than B. This variation in the amount of resin was the only difference which could be detected between the two samples. Both had evidently been carefully prepared, and their physical characters were exceedingly good. In composition they compare very favourably with other samples of rubber derived from *Landolphia Kirkii* which have been examined at the Imperial Institute.

The rubbers were submitted for valuation to brokers who reported that consignments represented by these specimens would command a very ready sale, and would probably realise as much as 4*s.* per lb. in the London market, with fine hard Para quoted at 4*s.* 8*d.* per lb.

II. (1906).

In continuation of the preceding enquiry a small consignment of "Ibungu" rubber prepared from *Landolphia Kirkii* in Amatongaland, Natal, was forwarded to the Imperial Institute in order that it might be chemically examined and subsequently sold in the London market.

The rubber was in the form of balls or spindle-shaped pieces, and had a distinct reddish colour. When cut, the pieces were found to be light pink internally, and to contain a perceptible amount of moisture. The rubber was fairly free from vegetable impurity, although a few of the balls examined contained large pieces of bark. The physical characters of the rubber were very satisfactory.

A representative sample of the rubber gave the following results on chemical examination:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	12·1	—
Caoutchouc	73·6	83·7
Resin	9·1	10·4
Proteid	1·1	1·3
Insoluble matter ...	4·1	4·6
Ash	0·38	0·43

The analysis showed that the rubber was of good quality, and the figures given above agree closely with those furnished by the two previous samples of the same rubber examined at the Imperial Institute.

The consignment was described by brokers as fine, red, clean rubber of very saleable quality, and it realised the very satisfactory price of 4*s.* 3*d.* per lb., the highest price obtained at the auction for this class of rubber being 4*s.* 6*d.* per lb.

It is evident from this and previous investigations that the rubber furnished by *Landolphia Kirkii* in Amatongaland is of very good quality, and that if carefully prepared it will command a satisfactory market. The price realised will of course depend upon the quality of individual consignments and upon market fluctuations.

TRANSVAAL.

Landolphia Rubber from the Northern Transvaal (1910).

The sample weighed 1¼ lb. and consisted of an irregular mass of rubber, composed of an aggregation of small balls. The balls were light reddish-brown externally, and some of the larger pieces were white and moist within; a small quantity of vegetable impurity was present. The rubber exhibited good elasticity and tenacity.

An analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	5·8	—
Caoutchouc	81·0	86·0
Resin	8·9	9·4
Proteid	1·2	1·3
Insoluble matter ...	3·1	3·3
Ash	0·32	0·34

The rubber was valued at 4*s*. 6*d*. per lb. in London, with fine hard Para quoted at 7*s*. 7*d*. per lb.

The analysis shows that this rubber is of very fair quality, the dry material containing 86 per cent. of caoutchouc. The percentage of resin is, however, a little high. Consignments of rubber of similar quality would be readily saleable.

RHODESIA.

I.—"*Muteke*" *Rubber from North-Eastern Rhodesia* (1904).

Two small samples of this rubber, together with specimens of the leaves, flowers, and fruits of the plant yielding it, were forwarded to the Imperial Institute for analysis and valuation. The following information regarding the plant and the method of preparing the rubber was furnished.

"The 'Muteke' or 'Mutecha' plant yielding this rubber is a large creeper, having a small bright-green leaf with a highly-glazed finish on the top, but dull underneath. The berry is about the size of a small plum. As far as I can discover, the natives are not aware that rubber can be extracted from the root and branch (stem) of this plant. The berry when plucked exudes a white milky fluid which is not rubber. On cutting the bark from the stem and making an incision, the rubber flows in a liquid form. This, on being spread over the arms and chest, takes a solid form, and can then be rolled into a ball in the usual manner. From what I have seen I should say that the stem contains more rubber than the root. The larger specimen of rubber sent is from the branch, the small ball is mixed root and stem. The creeper, which grows to a large size (about a foot in circumference), is said to be common all over the Abercorn Division."

The specimens of the leaves, flowers, and fruits of the vine were not in sufficiently good condition to permit of an exact

determination being made, but it appeared that the "Muteke" plant was a species of *Landolphia*.

The sample of rubber consisted of two small balls, one of which had been derived from a large branch and the other partly from the root and partly from the stem. The two balls were not markedly different in appearance or properties. The rubber was dark reddish-brown, quite dry and free from stickiness, and contained very little foreign vegetable matter; it exhibited good elasticity and tenacity.

It would have been desirable to submit both samples of rubber to chemical examination, but the specimen obtained from root and stem was too small for this purpose, and consequently only the ball derived from a large branch was analysed. It gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·6	—
Caoutchouc	79·7	83·6
Resin	12·0	12·5
Insoluble matter ...	3·7	3·9
Ash	0·4	0·5

These results show that this rubber is of fair quality. The amount of resin present is rather higher than is desirable, but the caoutchouc reaches the fairly high figure of 83·6 per cent. in the dry material.

The quantity of the material available was insufficient to permit of samples being sent to brokers for valuation, and consequently the exact commercial value of the rubber cannot be stated, but it is probable that it would fetch about 3*s*. per lb. in London, with fine hard Para quoted at 5*s*. 3*d*. per lb.

The foregoing results, though somewhat inconclusive owing to the smallness and unsatisfactory character of the specimens sent for examination, are sufficient to indicate that this rubber is of fair quality and likely to be of considerable commercial value.

In order that its exact value might be ascertained, it was suggested that a further sample of at least 2 lb. of the rubber should be collected and forwarded to the Imperial Institute for chemical examination, together with carefully prepared botanical specimens showing the leaves, flowers, and fruits of the "Muteke" plant.

II.—"*Muteke" Rubber from North-Eastern Rhodesia* (1905).

In continuation of the investigation of "Muteke" rubber recorded in the preceding report, larger samples of the rubber and further botanical specimens of the vine were forwarded from North-Eastern Rhodesia.

Three specimens of the "Muteke" vine were furnished, and these bore the following labels:—

(1) "Leaves of rubber-yielding (female) 'Muteke' vine, Mwaba, Chambesi River, April 23, 1905."

(2) "Leaves of non-rubber-yielding (male?) 'Muteke' vine, Mwaba, Chambesi River. April 23, 1905."

(3) " 'Muteke,' bushy form, from stony hills, Mirongo. Top sprigs with young leaves and buds. November, 1904."

These specimens were referred for identification to the Director of the Royal Gardens, Kew, who reported that (1) and (2) are *Landolphia Kirkii*, Dyer. This vine is one of the most important sources of rubber in East Africa, where it is widely distributed. In the letters accompanying the specimens it is stated that differences have been observed in the rubber-yielding properties of the "Muteke" vines, and that in consequence the terms "male" and "female" have been applied to the two varieties. Nothing appears to have been recorded previously regarding such differences in the case of *Landolphia Kirkii*, and further observations upon this point would therefore be of interest. The bushy form of "Muteke" (3) is shown to belong to a different species, *Landolphia parvifolia*, K. Schum., the value of which as a source of rubber is a little doubtful at the present time. It has been stated that this plant does not yield rubber, but, on the other hand, it is included by some authorities among the species which furnish the "root-rubber" of commerce, and it would be desirable to conduct experiments in Rhodesia to determine this point.

The sample submitted for examination consisted of 1½ lb. of rubber in small balls, each about 1½ inches in diameter. Two pieces of old rubber obtained from the natives were also forwarded, but these were too small for separate examination, and were not included in the sample selected for analysis. The rubber was light brown, fairly clean and free from stickiness, and possessed good physical properties.

A representative sample of the rubber was examined and found to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	14·9	—
Caoutchouc	69·1	81·2
Resin	8·7	10·2
Proteid	1·7	2·0
Insoluble matter ...	5·6	6·6
Ash	0·9	1·0

These figures are in general agreement with those obtained in the examination of the previous specimen, and prove that the rubber is of very fair quality. The present sample contains a lower percentage of resin than that previously found, 10·2 compared with 12·5, but owing to the fact that it includes a larger amount of vegetable impurities the percentage of caoutchouc is approximately the same.

The rubber was submitted for valuation to commercial experts, who classed it as "good clean ball of Nyasa character," and worth about 3*s.* 10*d.* per lb. in London, with fine hard Para quoted at 5*s.* 7*d.* per lb.

III.—"*Dande*" *Rubber from Rhodesia* (1903 and 1905).

A number of products allied to rubber and gutta percha have been forwarded to the Imperial Institute from Rhodesia for the purpose of ascertaining whether any of them were likely to be of commercial value. Among the earliest specimens submitted was a small sample of genuine rubber, which was forwarded from the Umtali District, and was stated to be obtained from a plant known locally as "Dande." The rubber, which had been collected upon a twig, was dark brown, rather soft and sticky, and somewhat deficient in tenacity. An analysis gave the following figures:—

	Per cent.
Moisture	1·2
Caoutchouc	88·3
Resin	7·0
Insoluble matter	3·5
Ash	1·7

These results indicated that so far as chemical composition was concerned the rubber was of very fair quality, and would be readily saleable in the market, especially if better prepared so as to avoid the stickiness shown by the specimen submitted.

A larger sample of the rubber and botanical specimens of the plant yielding it were accordingly requested, so that the quality and value of the rubber could be definitely ascertained and its botanical source determined. These specimens were subsequently received, and their examination furnished the following results.

The second sample of the "Dande" rubber from the Umtali District consisted of a single ball, about 2½ inches in diameter, and weighing 5½ oz. The ball was light reddish-brown externally, but when cut it was found to be white at the centre and rather moist. The rubber exhibited very good physical properties.

Its composition as determined by chemical examination was as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	15·5	—
Caoutchouc	68·1	80·7
Resin	10·7	12·6
Insoluble matter ...	5·7	6·7
Ash	1·6	1·9

The rubber was therefore of very fair quality, containing 80·7 per cent. of caoutchouc and 12·6 per cent. of resin in the dry material. It was not equal in chemical composition to the small sample previously examined, which contained 88 per cent. of caoutchouc and only 7 per cent. of resin, but it was much superior in physical characters.

The rubber was submitted for valuation to brokers, who reported that consignments of similar quality would fetch about 3*s*. 6*d*. per lb. in the London market, the current quotation for Para rubber being 4*s*. 9*d*. per lb.

It seems clear from these results that this plant yields marketable rubber of good quality, and, if abundant in Rhodesia, it should prove a valuable source of that material.

The botanical specimens of the " Dande " plant were forwarded to the Royal Botanic Gardens, Kew, for identification. It proves to be a species of *Landolphia* closely resembling *Landolphia Petersiana,* Dyer, but its exact identity could not be determined, as the specimens did not show the flowers or fruits of the plant in a sufficiently well-developed condition.

IV.—*Rubber of* Landolphia Kirkii, *Dyer, from Southern Rhodesia* (1904).

This specimen consisted of a single ball of reddish-brown, fairly hard, dry rubber, containing a considerable proportion of foreign vegetable matter. It was not sticky and exhibited fair elasticity and tenacity.

On analysis it was found to have the following composition:—

	Per cent.
Moisture	0·8
Caoutchouc	79·1
Resin	6·2
Insoluble matter	13·9
Ash	0·3

This rubber contained more resin and insoluble matter than is usually present in the Landolphia rubbers now on the market.

The quantity of material supplied was too small to permit of an exact commercial valuation of the rubber being made, but it is probable that it would fetch from 2*s*. 9*d*. to 3*s*. per lb., with fine hard Para at 5*s*. per lb.

V.—*Landolphia Rubber from Mashonaland* (1905).

This was a small sample of rubber which had been collected by rolling on a twig. It was dark brown, rather soft and sticky, and did not exhibit much tenacity; it was fairly free from extraneous vegetable matter.

On chemical examination it furnished the following results:—

	Per cent.
Moisture	1·2
Caoutchouc	88·3
Resin	7·0
Insoluble matter	3·5
Ash	1·7

This analysis shows the rubber to be of good quality, and if obtainable in quantity and less sticky there is little doubt that it would be readily saleable.

PORTUGUESE EAST AFRICA.

Landolphia Rubber, probably Landolphia Kirkii (1910).

No. 1. " Smoked rubber collected from Landolphia, probably *Landolphia Kirkii.*"

One large and three small balls of rubber, together weighing 5 oz.

The large ball was stated to have been collected in the Low Veld, Madanda, and the small balls in Mafusi in the High Veld. There was no difference in the rubber from the two sources.

The rubber was reddish-brown, of good appearance, and very satisfactory in physical properties.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	5·0	—
Caoutchouc	85·6	90·1
Resin	5·4	5·7
Proteid	1·3	1·3
Insoluble matter ...	2·7	2·8
Ash	0·46	0·48

These figures show that the rubber is of very good quality, the dry material containing 90 per cent. of caoutchouc, whilst the percentages of resin and proteid are low.

The rubber was valued by brokers at 4*s*. to 4*s*. 1*d*. per lb., with fine hard Para at 4*s*. 2½*d*. per lb.

No. 2. "Unsmoked rubber collected from Landolphia, probably *Landolphia Kirkii*."

One large and three small balls of rubber, together weighing 5 oz.

No difference could be detected between the large and small balls, which were obtained from the two sources indicated in connection with specimen No. 1.

This rubber is very similar to the previous specimen but is of rather duller colour.

The specimen was not analysed. It was valued by brokers at 3*s*. 11*d*. to 4*s*. per lb., with fine hard Para at 4*s*. 2½*d*. per lb.

A comparison of these two Landolphia rubbers shows that the smoked specimen is of rather better appearance and would on that account fetch a slightly increased price. It cannot, however, be definitely stated from the results of these small experiments that the smoking of Landolphia rubber would be generally beneficial, and further trials on a larger scale should be made.

SEYCHELLES.

Landolphia Rubber (1908).

Two specimens of rubber derived from a species of Landolphia (Vahea) have been examined at the Imperial Institute. The vine was introduced into Seychelles from Madagascar and is stated to grow luxuriantly, but the cost of preparing the rubber in a clean form is practically prohibitive. The results of the investigation will, however, be of interest.

"No. 1. Vahea rubber obtained by pounding the bark." Weight, 12 oz.

An irregularly-shaped piece of dark brown rubber, resembling scrap rubber in appearance, and containing a considerable quantity of bark. The rubber exhibited good elasticity and tenacity. The results of the chemical examination were as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·2	—
Caoutchouc	81·7	83·5
Resin	5·2	5·3
Proteid	1·8	1·8
Insoluble matter ...	9·1	9·4
Ash	1·1	1·1

The value of the rubber was given as probably about 3*s*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

This rubber is of good quality, the only defect being the large amount of vegetable impurity present in it owing to the method of preparation.

"No. 2. Vahea rubber obtained by tapping." Weight, 1 oz.

A small biscuit of clean brown rubber, the physical properties of which were very satisfactory.

The composition of the rubber was as follows:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·2	—
Caoutchouc	88·0	90·9
Resin	7·7	7·9
Proteid	0·8	0·8
Insoluble matter ...	0·3	0·4
Ash	0·3	0·3

The specimen was valued at about 4*s*. to 4*s*. 3*d*. per lb. in London, with fine hard Para quoted at 4*s*. 7*d*. per lb.

The rubber prepared in this form is of much better quality than No. 1, owing to the absence of vegetable impurities, and would realise a higher price. The results of the analysis are very satisfactory, but it is noteworthy that the percentage of resin is considerably higher than in No. 1.

ASIATIC VINE RUBBERS.

INDIA.

1.—*Rubber of* Urceola esculenta, *Benth., from Rangoon* (1903).

The specimen was an irregular mass of rubber, almost black externally but presenting a mottled appearance when cut, being nearly white in places. The mass was very hard and showed no stickiness; it was slightly porous, and contained a quantity of vegetable matter distributed through it. The rubber exhibited good elasticity and tenacity.

It furnished the following results on chemical examination:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	6·9	—
Caoutchouc	76·2	81·8
Resin	7·0	7·5
Insoluble matter ...	9·9	10·7
Ash	1·7	1·8

These results show that the rubber is of very fair quality, though the amount of insoluble matter is rather high. This, however, could be remedied to a large extent by more careful collection so as to exclude vegetable debris.

A sample of the rubber was submitted for commercial valuation to brokers who compared it with "Tonquin" rubber worth about 2*s*. or 2*s*. 1*d*. per lb., with fine hard Para at 3*s*. 2*d*. per lb. They state, however, that large consignments of this type of rubber rarely arrive in such good condition as the present sample, being usually more or less damaged by changes occurring during transport, in which case the value would be considerably reduced, and sales more difficult to effect.

II.—*Rubber of* Urceola esculenta, *Benth., from Burma* (1904).

Five specimens of this rubber, prepared by different methods in three districts of Burma, were forwarded to the Imperial Institute for examination.

Description of Samples.

No. 1. This sample, which had been treated with creosote, was forwarded from Bassein, Burma, by the Conservator of Forests. It consisted of four flat cakes, together weighing 2 oz., which were dark brown in colour. The rubber was evidently of rather inferior quality, being soft and very deficient in elasticity and tenacity.

No. 2. This was of similar origin to No. 1, but had been prepared with acetic acid in place of creosote. The sample consisted of three circular cakes, weighing about 2 oz., which were dark brown and covered with mould on the surface. In physical characters the rubber was similar to the preceding specimen.

No. 3. This sample, which had been prepared by the Conservator of Forests in the Pegu Division, Burma, was found to include three distinct forms of rubber, differing somewhat in quality. These were consequently separated and an analysis made of each. For convenience of reference they are marked A, B, and C.

A. *Four large rolls, weighing about* 18 *oz.*—The rubber was almost black, very porous, and contained a little vegetable matter and much acid liquid. It was very elastic and tenacious.

B. *Cakes made up of shreds of rubber, together weighing about* 1 *lb.*—These consisted of aggregations of shreds of rubber of reddish-brown colour; when cut the cakes were found to be slightly moist and also to contain a small amount of vegetable

matter. The rubber was of good quality, being free from stickiness and exhibiting considerable elasticity and tenacity.

C. *Balls of compact rubber, weighing about* 17 *oz.*—The balls were almost black externally, but when cut they showed irregular white patches scattered through the section, and were rather moist. A quantity of vegetable matter was also present. The rubber exhibited very good physical properties.

No. 4. This sample was forwarded by the Conservator of Forests, Pegu Division, Burma. It consisted of two flat cakes, each about six inches in diameter, and together weighing 5 oz. The rubber was dark brown and had a strong odour of creosote; it was slightly sticky, but was strong and exhibited good elasticity and tenacity.

No. 5. This was prepared by the Conservator of Forests, Tenasserim Division, Burma. The sample consisted of two thin sheets of rubber, weighing about 1 oz., and having a distinct odour of naphthalene. The rubber had a reddish-brown colour and its physical characters were exceedingly good.

Results of Examination.

The analyses of the rubbers furnished the following percentage results:—

No.	Rubber as received.					Composition of dry rubber.			
	Moisture.	Caoutchouc.	Resin.	Insoluble matter.	Ash.	Caoutchouc.	Resin.	Insoluble matter.	Ash.
No. 1 ...	1·9	54·0	42·6	1·5	0·64	55·0	43·4	1·6	0·65
No. 2 ...	0·9	52·1	45·5	1·5	0·56	52·6	45·9	1·5	0·56
No. 3 A ...	11·6	70·7	12·1	5·6	1·86	79·9	13·7	6·4	2·40
No. 3 B ...	5·9	76·4	10·9	6·8	1·32	81·2	11·6	7·2	1·40
No. 3 C ...	9·7	73·7	8·3	8·3	2·03	81·6	9·2	9·2	2·24
No. 4 ...	2·6	75·7	18·0	3·7	1·02	77·7	18·5	3·8	1·04
No. 5 ...	4·0	80·5	9·8	5·7	1·16	83·9	10·2	5·9	1·21

These figures show that Nos. 1 and 2 are of very inferior quality, containing 43·4 and 45·9 per cent. of resin respectively in the dry material, and they would therefore only possess a low commercial value. The amount of resin present in these two samples from Bassein is very much greater than in any of the other specimens, and from later information it appears that the botanical source of these two specimens is rather doubtful and may not be *Urceola esculenta* as was first stated. The other samples are all of fairly good quality, so far as chemical composition is concerned, though in No. 4, from the Pegu Division, the percentage of resin is higher than would be desirable in commercial consignments. In the remaining analyses the resin ranges from 9·2 to 13·7 per cent. and the caoutchouc from 79·9 to 83·9 per cent. The three kinds of rubber included in sample No. 3 vary slightly in composition, particularly in the amount of resin present.

It may be noted that the sample of this rubber previously examined was found to contain 7·5 per cent. of resin and 81·8 per cent. of caoutchouc, so that although some of the present specimens give a higher percentage of caoutchouc than this, they all contain more resin.

Commercial Value.

Representative samples of the rubbers, excepting Nos. 1 and 2 which were of much poorer quality than the others, were submitted for valuation to brokers, who were informed of the result which had been obtained on analysis. They reported that the value of the specimens in the London market would be as follows:—

	Price per lb.	Remarks.
No. 3 A ...	About 3*s.* 2*d.* ...	"Tonquin character."
,, 3 B ...	,, 3*s.* 6*d.* ...	"Red Tonquin ball character; inclined to be heated, which would greatly affect its value."
,, 3 C ...	,, 3*s.* 0*d.* ...	"Dark ball, slightly gummy and not well cured; might be difficult to sell at ordinary times."
,, 4 ...	... 3*s.* 6*d.* ...	"Thick biscuit, strong; would command a ready sale."
,, 5 ...	... 4*s.* 0*d.* ...	"Thin sheet, fairly strong; would fetch a good price if not heated."

These valuations are much higher than that obtained for the previous specimen, owing to the fact that the market value of all grades of rubber has risen in the interval. For comparison with the above quotations it may be mentioned that the current value of fine hard Para rubber was 4*s.* 8*d.* per lb.

It is quite clear, however, from the preceding analyses and valuations that marketable rubber of good quality can be obtained from *Urceola esculenta* in Burma.

III.—*Rubber of* Chonemorpha macrophylla, *G. Don* (1904).

This sample of the rubber of *Chonemorpha macrophylla* was prepared by the Conservator of Forests in Tenasserim, Burma who reported that the plant is not uncommon in the Tenasserim Division, but is being rapidly exterminated.

The sample consisted of a small conical piece of rubber which was dark brown externally but almost white and slightly moist within. The rubber was rather sticky, but exhibited fairly good elasticity and tenacity.

The analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	8·0	—
Caoutchouc	55·2	60·0
Resin	34·6	37·6
Insoluble matter ...	2·2	2·4
Ash	0·97	1·05

The rubber, therefore, contains a large amount of resin, over 37 per cent. in the dry material, and it is consequently of inferior quality. No definite conclusions regarding the quality and value of the rubber can be drawn, however, from the results of the examination of such a small sample as that submitted in the present case, and it would be desirable to collect and forward a much larger quantity for further investigation. A larger sample would be more representative of the average quality of the rubber, and could be submitted to brokers for commercial valuation, for which purpose the present specimen was too small.

Chonemorpha macrophylla has been known for many years as a rubber-yielding plant, and some information regarding it has been recorded. It has been recommended in certain quarters as suitable for cultivation, but from the experiments at Buitenzorg, where there is a plantation of the vines, this would appear to be doubtful, as the plant is stated to interfere with the development of the tree upon which it grows, and its increase in thickness is slow. It appears to be agreed, however, that the rubber which it furnishes is of good quality, but the collection is stated to be difficult, owing to the rapidity with which the latex coagulates in the cuts.

IV.—*Rubber of* Rhynchodia Wallichii, *Hook. f.* (1904):

This sample of rubber was prepared from *Rhynchodia Wallichii* in Shewegyin, Tenasserim, Burma.

Several notices have recently appeared regarding the rubber-yielding properties of this plant, which is reported to be fairly common in the Pegu Division, and the rubber obtained from it has been described as of good quality.

The sample received for examination consisted of an irregular cake which was slightly mouldy on the surface. The rubber was dark brown throughout, and contained a small amount of vegetable matter. Its physical properties were very satisfactory, it being quite free from stickiness and exhibiting good elasticity and tenacity.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	2·8	—
Caoutchouc	86·5	89·0
Resin	6·5	6·7
Insoluble matter ...	4·2	4·3
Ash	0·48	0·51

These results show that this specimen of the rubber of *Rhynchodia Wallichii* is of good quality, as the dry material contains 89 per cent. of true caoutchouc and only 6·7 per cent. of resin.

The rubber was submitted for commercial valuation to brokers who reported that consignments of similar quality would sell readily in the London market at about 3*s*. 6*d*. per lb., with fine hard Para quoted at 4*s*. 8*d*. per lb. There is no doubt that the rubber of *Rhynchodia Wallichii*, if of similar quality to the present sample, would always sell readily and command a good

price in the market. The plant is reported to be common in certain districts of Burma, and it therefore appears to be worthy of attention as a possible source of rubber.

V.—*Rubber of* Ecdysanthera micrantha, *A. DC.* (1905).

A very small specimen of the latex of this plant which had been collected at the instance of the Conservator of Forests, Tenasserim Circle, Rangoon, was forwarded to the Imperial Institute for examination.

This plant, known in Burma as "Nwedo," is a climber or vine, and has only been definitely recognised as a source of rubber during the last few years. It is stated to occur in Assam, Burma, Siam, Southern China, and French Indo-China, and in the last-named country it is exploited by the natives for its rubber. Some information concerning the vine and the native methods of preparing rubber from it has been published by the French officials, but no analyses of the product appear to have been made.

On arrival in this country, the sample had already undergone partial coagulation with the formation of a small quantity of rubber, and very little of the fluid latex remained for examination. Experiments with the small quantity available showed that the latex could be readily coagulated by the application of gentle heat, and this method could be easily employed for the preparation of the rubber upon a large scale. Care would have to be taken, of course, to avoid overheating the rubber, and in order to ensure this in practice it would be desirable to effect the coagulation by immersing the vessel containing the latex in boiling water. The rubber thus obtained should be well washed and pressed, and then dried in the shade as thoroughly as possible before shipment.

The rubber furnished by the spontaneous coagulation of the latex, together with that obtained on heating the residual liquid, was well pressed to remove as much moisture as possible, and was then dried by exposure to the air. After this treatment the total yield weighed 7·5 grams, about 25 per cent. of the weight of the original latex. Judged by its physical properties the rubber was of very fair quality, as it was free from stickiness and exhibited fairly good elasticity and tenacity.

The chemical examination of the dry material gave the following results:—

	Per cent.
Caoutchouc	84·1
Resin	11·5
Insoluble matter	4·4
Ash	1·3

This analysis shows that the rubber contained 84 per cent. of caoutchouc, which was of very good quality, and 11·5 per cent. of resin, and confirms the opinion of its quality based upon its physical properties. The percentage of resin is rather higher than is desirable, but further analyses will be necessary before the above result can be accepted as representative.

VI.—*Rubber of* Parameria glandulifera, *Benth.*

Parameria glandulifera is a climbing plant, distributed through Southern Burma, Indo-China, and the Malay Peninsula, which

has long been known to yield good rubber, and is, in fact, exploited for this product by the native collectors. Samples of the latex and rubber of this plant have been forwarded for examination to the Imperial Institute from Burma and the Andaman Islands respectively.

Latex of Parameria glandulifera *from Burma* (1905).

The latex was a milky fluid possessing a slightly sour odour. It had undergone partial coagulation during transit with the production of a cake of rubber, which after drying was found to weigh 45 grams, whilst the residual latex, measuring 400 c.c., still furnished 8 per cent. of dry rubber. The total amount of dry rubber obtained from the sample was therefore 77 grams, which represents a yield of about 19 per cent. from the latex.

The latex was partially coagulated on boiling or by heating in boiling water. The addition of a small quantity of a mineral acid, dilute sulphuric or hydrochloric, caused complete coagulation at once in the cold, the rubber separating and leaving a slightly turbid liquid; alchohol produced a similar result. Acetic acid had little effect in the cold, but coagulation was readily induced when the acidified latex was gently warmed. The addition of sodium sulphate, magnesium sulphate, or sodium chloride caused the latex to cream completely on standing, the rubber particles separating and forming a distinct layer on the surface without coalescing, but on removing the liquid by straining, the particles aggregated to form a clot of rubber. It may be mentioned that the fresh latex of this plant collected in French Cochin-China by M. Pierre was found to be readily coagulated by gentle heat even after dilution with water.

The rubber obtained from the latex had a light brown colour after drying, was free from stickiness, and exhibited very good elasticity and tenacity. From its physical characters it appeared to be of good quality.

The results of the chemical examination of the dry rubber are given in the following table:—

	Per cent.
Caoutchouc	91·8
Resin	6·3
Proteid	1·4
Ash	0·5

These figures confirm the opinion of the quality of the rubber based on its physical properties.

Rubber of Parameria glandulifera *from the Andamans* (1906).

Parameria glandulifera is very common in the forests of the Andamans, but the exploitation of the vine for its rubber is stated to present some difficulty.

The sample of rubber forwarded to the Imperial Institute had, unfortunately, undergone deterioration during transit, and on arrival in this country its physical condition was unsatisfactory. It consisted of 15½ lb. of rubber in balls, which ranged from 2 to 3 inches in diameter. The balls were almost black externally,

but whitish and fairly moist within when freshly cut; they were exceedingly sticky on the outside, and showed signs of considerable over-heating. The rubber from the centres of the balls was almost free from stickiness, and exhibited very good elasticity and tenacity.

The chemical examination furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	15·3	—
Caoutchouc	77·6	91·6
Resin	4·9	5·8
Proteid	1·6	1·9
Ash	0·6	0·7

It will be seen that the sample of the rubber of *Parameria glandulifera* from the Andamans is of very good quality so far as chemical composition is concerned, and corresponds closely with the product prepared from the latex received from Burma. The percentages of resin and proteid are low, and the rubber is free from vegetable impurities.

The investigation of these samples has shown that the rubber furnished by *Parameria glandulifera* is of good quality, judged by its chemical composition, and there is no doubt that, if carefully prepared, the product would realise satisfactory prices in the market.

VII.—*Rubber of* Parameria pedunculosa, *Benth.* (1905.)

A small specimen of the latex of this climbing plant, collected at the instance of the Conservator of Forests, Tenasserim Circle, Rangoon, was forwarded to the Imperial Institute for examination.

The vine, known as "Kamanoo" in Burma, has also been described as *Ecdysanthera pedunculosa*, Miquel, and has been stated by van Romburgh to furnish good rubber in Java and Sumatra. No other experiments appear to have been made upon the vine.

The latex had completely solidified before being despatched from Burma, and was received here as a pinkish-white curdy substance, which, after drying on a porous plate, formed a friable powder. The material, therefore, possessed none of the physical properties of rubber, but softened and became adherent when placed in hot water.

The composition of the dry material was as follows:—

	Per cent.
Resin	88·5
Caoutchouc	10·7
Insoluble matter	0·8
Ash	0·3

The product is therefore of very resinous character, containing only 10·7 per cent. of caoutchouc, which, moreover, was sticky and of inferior quality. Material possessing this composition and

character would have very little commercial value, but, in view of the favourable opinion which has been expressed regarding the product from this vine in Java and Sumatra, further investigation appears to be desirable.

Further experiments should be made to determine the character of the product furnished by the latex of this vine. It is stated by the Conservator of Forests that the latex coagulates very shortly after collection, so that it cannot be strained in the factory to remove dirt. This could probably be prevented by diluting the latex with water at the time of collection and afterwards inducing coagulation, if this does not occur on standing, by gentle heat, as in the case of the latex of *Parameria glandulifera*, or by the addition of a suitable chemical coagulant. Analyses of the samples thus obtained would enable the nature of the material to be definitely ascertained.

VIII.—*Rubber of* Willughbeia edulis, *Roxb.* (1903).

This specimen of the rubber of *Willughbeia edulis* was supplied by the Deputy Conservator of Forests in the Rangoon Division. It was not homogeneous, but consisted principally of small lumps of a soft black substance which was somewhat elastic and could be pulled out into threads. In addition a quantity of light grey powder was present, chiefly on the outside of the lumps, and this appeared to have been formed from the black material by exposure to air; when worked between the fingers it became coherent, almost black in colour, and sticky, and did not return to a friable condition even after standing for a considerable time.

The material did not exhibit the physical properties of either rubber or gutta percha and was evidently of a very resinous nature. It dissolved completely, excepting the extraneous vegetable matter present, in chloroform and ether, but was only partially soluble in hot alcohol or acetone.

An analysis made by the usual method adopted for a rubber furnished the following results:—

	Per cent.
Moisture	0·6
Resin (portion soluble in hot acetone)...	84·0
Caoutchouc (portion dissolved by chloroform from residue insoluble in acetone)	10·8
Insoluble matter	4·6
Ash	0·6

The portion insoluble in acetone but dissolved by chloroform did not resemble ordinary caoutchouc in appearance or properties; it was soft, sticky, and inelastic.

The material is therefore of very inferior quality, being principally composed of resinous substances, and it would have little or no commercial value.

IX.—*Rubber of* Cryptostegia grandiflora, *R. Br.* (1903 and 1906).

Three samples of the rubber of *Cryptostegia grandiflora*, received from India, have been examined at the Imperial Institute.

No. 1. Sample from Madras. This sample consisted of three flattened cakes, weighing together about 1 lb. They were dark brown externally, but much lighter and slightly porous within; the pores contained a small amount of uncoagulated latex and a quantity of dark brown liquid having an acid reaction; a little vegetable impurity was also present. The rubber on arrival was soft but not sticky, very elastic, and possessed fair tenacity. After keeping for some time, however, it hardened a little and then exhibited a tendency to tear when stretched.

A chemical examination gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	24·7	--
Caoutchouc	67·4	89·5
Resin	5·9	7·9
Insoluble matter ...	2·0	2·6

It will be seen from these figures that the rubber is of very fair quality, the dry material containing 7·9 per cent. of resin and 89·5 per cent. of caoutchouc. The amount of moisture in the sample as received was excessive, but this could be remedied by more careful preparation.

A sample of the rubber, together with a statement of the above results, was submitted for commercial valuation to brokers, who reported that it would be worth about 2*s*. 4*d*. per lb. in London (August, 1903).

No. 2. Sample from Jalaun. This sample was an irregular mass of rubber, almost black throughout, porous but quite dry, and contained fragments of bark distributed through it. The rubber was rather soft and slightly sticky; it exhibited very fair elasticity, but was somewhat deficient in tenacity. As in the case of the specimen from Madras the tenacity of the rubber diminished on keeping.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	5·5	—
Caoutchouc	79·9	84·5
Resin	8·5	9·0
Insoluble matter ...	6·1	6·5

The sample from Jalaun therefore contained more resin and foreign matter than that from Madras, and its physical characters were not quite so satisfactory. The brokers to whom it was submitted valued it at 1*s*. 6*d*. per lb. compared with 2*s*. 4*d*. per lb. for the Madras specimen.

No. 3. Sample from Bombay. It is stated that the climbing plant *Cryptostegia grandiflora* is very common in the Bombay Presidency, and that if the rubber is of marketable quality large supplies could be obtained.

The sample weighed about 13 oz., and consisted of a large porous lump of rubber which had been formed apparently by

the aggregation of thin sheets and scrap. It was dark coloured, slightly sticky, and contained a considerable quantity of vegetable and mineral impurities. The rubber exhibited very fair elasticity and tenacity.

The rubber was found to have the following composition:—

	Per cent.
Moisture	3·6
Caoutchouc	64·3
Resin	10·1
Proteid	7·9
Insoluble matter	14·1
Ash	8·22

The percentages of resin and proteid are both high, but the chief defect of the rubber is the presence of the large amount of insoluble matter, consisting of vegetable and mineral impurities. The presence of mineral impurity points to the contamination of the rubber, possibly the scrap rubber present in the sample, by contact with the soil, and precautions should be taken to avoid this in future. The percentage of caoutchouc is rather low, but this is chiefly due to the excessive amount of the impurities contained in the present sample.

A sample of the rubber was submitted for valuation to brokers, who reported that it was rather sticky and slightly heated, and would probably be worth 3*s*. 6*d*. per lb. in London, with fine hard Para from South America quoted at 5*s*. 4*d*. per lb.

Formosa.

Rubber of Ecdysanthera utilis (1907).

The specimen weighed 15 oz. and consisted of a number of small irregular pieces formed by the aggregation of strips of reddish-brown rubber; the majority of the pieces were sticky externally and contained a fair amount of bark. The rubber exhibited good elasticity and tenacity, but the external sticky portions were weak.

An analysis furnished the following results:—

	Per cent.
Moisture	1·3
Caoutchouc	85·3
Resin	5·0
Proteid	2·1
Insoluble matter	6·3
Ash	1·41

The rubber was described by brokers as "slightly barky and heated throughout," and was valued at 3*s*. 3*d*. per lb. in London, the current price of fine hard Para being 4*s*. 7*d*. per lb.

The results of the analysis show that this rubber is of good quality so far as chemical composition is concerned, and if carefully collected there is no doubt that it would realise good prices. The sticky nature of the present sample, probably due to over heating, reduces its value considerably. Care should be taken during collection to avoid the inclusion of any considerable quantity of bark with the rubber.

WEST INDIAN VINE RUBBER.

RUBBER OF *Forsteronia floribunda* FROM JAMAICA (1908).

A sample of the rubber of *Forsteronia floribunda* prepared in Jamaica has been examined at the Imperial Institute.

The plant is stated to grow profusely in the limestone districts of Jamaica, and it was consequently desired to ascertain whether a market could be found for the rubber, and what its commercial value would be.

The sample, which weighed about 13 oz., consisted of two small sheets and one larger cake of rubber. The sheets were dark-coloured throughout and quite dry, whereas the cake was white and moist internally. The rubber was clean, free from stickiness, and exhibited satisfactory physical properties; it smelt strongly of creosote, which had no doubt been used in its preparation.

The rubber had the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	10·8	—
Caoutchouc	79·3	88·8
Resin	6·3	7·1
Proteid	1·4	1·6
Insoluble matter ...	2·2	2·5
Ash	1·26	1·40

The analysis shows that the rubber is of good quality, the dry material containing nearly 89 per cent. of true rubber. The percentage of proteid is low, and the amount of resin not excessive.

The rubber was submitted for commercial valuation to brokers who reported that it would probably realise 2*s*. 4*d*. per lb. in London with fine hard Para from South America quoted at 3*s*. 5½*d*. per lb.

The results of the examination of this sample of Forsteronia rubber confirm the conclusions drawn from previous investigations. There is no doubt that the rubber furnished by this vine is of good quality, and, if obtainable in quantity, it would be readily saleable. Up to the present time the absence of a regular and sufficient supply has been the principal hindrance to the commercial exploitation of this rubber.

RUBBER OF *MASCARENHASIA ELASTICA*.

In 1898 a new rubber-yielding tree was discovered by Dr. Stuhlmann in the neighbourhood of Dar-es-Salaam, German East Africa, and from the botanical specimens which he collected the plant was determined by Dr. K. Schumann as a new species of Mascarenhasia to which the name *Mascarenhasia elastica* was given. The plant was described as a small tree, from 30 to 40 feet in height, with slender branches; the trunk usually branches low down and is covered with greyish bark. The leaves are opposite, oblong, obtuse or obtusely and shortly acuminate, acute at the base, and coriaceous; they vary from 3 to 10 inches long and from $1\frac{1}{4}$ to $2\frac{1}{2}$ inches broad.* The flowers are conspicuous and fragrant; the follicles are purplish-black and from 3 to $3\frac{1}{2}$ inches long.

Like other species of the genus, *Mascarenhasia elastica* furnishes rubber which is collected to some extent by the natives and is known as M'goa or Goa rubber in East Africa. It is stated, however, that the latex flows so slowly that the collection of the rubber is not profitable, and that owing to the crude methods employed the product is of inferior quality and low value.

Mascarenhasia elastica is reported to be fairly common in the neighbourhood of Dar-es-Salaam, growing principally on the banks of streams or in moist situations. The trees have smooth, straight trunks, which are used by the natives for building their houses, and it is for this purpose, rather than as a source of rubber, that they are chiefly prized.

Experiments which have been made in German East Africa on the cultivation of the tree have shown that it grows quickly even in dry soil, and that it flowers and fruits when five years old. The yield of latex at this age was, however, only small.

For some years after its discovery in German East Africa, *Mascarenhasia elastica* was not recorded from any other locality, but it has since been found in the East Africa Protectorate, the island of Pemba, and Portuguese East Africa, and specimens of the rubber furnished by the tree in these three countries have been examined at the Imperial Institute.

East Africa Protectorate (1907).

The discovery of *Mascarenhasia elastica* in the East Africa Protectorate was made in 1906 by Mr. E. Battiscombe, the Acting Conservator of Forests, who forwarded herbarium specimens of the plant to Kew, and a sample of the rubber to the Imperial Institute.

The tree is indigenous in parts of the forests of the Shimba Hills, to the south-west of Mombasa, and, as in German East Africa, it is usually found on the banks of streams or in moist situations. It here grows to a height of about 40 feet, and the trunk, which attains a diameter of about 18 inches, branches about 20 feet from the ground. The old trees have a thick, scaly bark, which can be easily removed; the inner bark is about $\frac{1}{4}$ inch thick and can be easily cut, but the latex exudes slowly.

The value of *Mascarenhasia elastica* as a source of rubber in the East Africa Protectorate is not fully determined, but experiments on this point and on the suitability of the tree for

cultivation are in progress. The trees are easily propagated from seed, which is produced freely, and they grow quickly, but they are not likely to succeed unless planted in moist valleys or on land bordering streams.

The specimen of rubber forwarded to the Imperial Institute by Mr. Battiscombe was a ball about 2¼ inches in diameter weighing 3½ oz.; it was formed of threads of rubber and contained a considerable amount of vegetable impurity. The rubber was light brown, and its physical properties were fairly satisfactory.

On analysis it was found to have the following composition:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	10·0	—
Caoutchouc	69·0	76·6
Resin	6·1	6·8
Proteid	3·5	3·9
Insoluble matter ...	11·4	12·7
Ash	2·29	2·54

These results show that the rubber would be of satisfactory composition, if it were not for the large amount of vegetable impurity included in it. This defect could, however, be easily remedied by careful collection.

The sample was valued at 3*s*. 6*d*. per lb. in London, with fine hard Para at 5*s*. 2*d*. per lb.

Pemba (1909).

Early in 1909 Mr. R. N. Lyne, the Director of Agriculture in Zanzibar, forwarded to the Imperial Institute botanical specimens of a rubber-yielding tree which had been discovered in the Weti District of Pemba by Said bin Issa, the Arab Governor of Weti. A small specimen of the rubber obtained from the tree was also submitted. From the herbarium specimens the tree was identified at Kew as *Mascarenhasia elastica*, K. Schum., which had not been previously recorded from Pemba. In response to a request for information concerning the occurrence of the tree in Pemba, Mr. Lyne furnished the following particulars.

The tree is known locally as "Mkeko," "Mlimi," and "Mnamiaziwa," the last name meaning "there is plenty of milk." It is fairly widely distributed through Pemba, but has not yet been discovered in Zanzibar island. It attains a height of about 40 feet, with a trunk one foot in diameter.

The natives had not recognised the possible value of the tree as a source of rubber, and large numbers of them have been cut down in making clearings. The tree appears, however, to possess considerable vitality, and shoots up quickly from the stump, even though cut back several times. The total number of Mascarenhasia trees in the island is not large, and many of them are little more than saplings, so that at present no considerable supply of rubber could be obtained from them. Experiments are, however, being made to determine the amount of rubber yielded by the trees and their suitability for cultivation, and

should these trials prove successful the natives may be induced to plant the trees.

The sample of the rubber forwarded by Mr. Lyne consisted of six small balls together weighing 8½ oz. The balls were dark brown externally, but lighter and rather moist within when freshly cut; only a small amount of vegetable impurity was present. The rubber exhibited good elasticity and tenacity.

The results of the chemical examination are given in the following table:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	15·8	—
Caoutchouc	71·7	85·2
Resin	7·6	9·0
Proteid	3·1	3·7
Insoluble matter ...	1·8	2·1
Ash	1·09	1·29

The results of the analysis show that this specimen of Mascarenhasia rubber from Pemba is of good quality, although the percentage of resin is a little high. It is superior in composition to the sample from the East Africa Protectorate, as it contains much less insoluble impurity, and the percentage of caoutchouc in the dry rubber is consequently higher.

The rubber was valued in London at 4*s.* per lb., with fine hard Para at 8*s.* 10*d.* per lb.

Portuguese East Africa (1908).

In 1907 Mr. W. H. Johnson, at that time Director of Agriculture to the Mozambique Company, discovered in the neighbourhood of Beira a rubber-yielding plant which has since been determined as a variety of *Mascarenhasia elastica*, K. Schum. It differs from the type in having the leaves more obtuse and the follicles with more or less incurved tips. The plant is described as a shrubby tree from 20 to 30 feet in height, with bright dark green leaves varying from 3 to 9 inches in length, and from 1 to 2 inches in breadth. The trees are stated to be fairly abundant in several districts of the Mozambique Company's territories, and they are named " N'harasika " by the natives.

Two specimens of ball rubber and three of smoked sheet obtained from trees growing in Portuguese East Africa have been examined at the Imperial Institute.

Ball Rubber.

(1) " Probably a Mascarenhasia."

A single ball of brown rubber, which contained a fair amount of vegetable impurity. The rubber was slightly sticky, but otherwise exhibited satisfactory physical properties.

(2) " N'harasika rubber: collected from *Mascarenhasia elastica*, K. Schum. variety."

Three small balls of brown rubber, clean and free from stickiness. The rubber exhibited good elasticity and tenacity.

The results of the chemical examination of these two specimens were as follows:—

—	Rubber as received.		Composition of dry rubber.	
	(1)	(2)	(1)	(2)
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6·6	1·4	—	—
Caoutchouc	75·5	90·8	80·8	92·1
Resin	6·0	4·5	6·5	4·6
Proteid	3·4	2·4	3·6	2·4
Insoluble matter ...	8·5	0·9	9·1	0·9
Ash	3·2	1·9	3·4	2·0

It is evident from these figures that sample (2) is of very good quality, the dry material containing 92 per cent. of caoutchouc and only small amounts of resin, proteid, and insoluble impurity. This specimen is in fact the best sample of *Mascarenhasia elastica* rubber which has been received at the Imperial Institute. A comparison of the results for samples (1) and (2) shows that the former is inferior in composition to the latter on account of the large proportion of insoluble matter present, and the higher percentages of resin and proteid.

The samples were too small for trustworthy valuation, but it was thought that consignments of similar character would realise from 2*s*. 9*d*. to 3*s*. 3*d*. per lb. in London, according to quality, with fine hard Para at 3*s*. 11½*d*. per lb.

Smoked Sheet Rubber.

(*a*) A sheet of dark brown rubber, about ¼ inch thick, with a strong smoky odour; it was rather moist internally when cut. The rubber exhibited good elasticity and tenacity.

(*b*) A sheet of rubber very similar to (*a*), but rather moister and lighter in colour.

(*c*) A sheet of rubber similar to (*a*).

The results of the analysis of these three specimens are given in the following table:—

—	Rubber as received.			Composition of dry rubber.		
	(*a*)	(*b*)	(*c*)	(*a*)	(*b*)	(*c*)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8·4	10·4	8·4	—	—	—
Caoutchouc	73·4	74·0	74·2	80·1	82·6	81·1
Resin	7·4	6·4	6·9	8·1	7·1	7·5
Proteid	3·6	3·4	3·5	3·9	3·8	3·8
Insoluble matter ..	7·2	5·8	7·0	7·9	6·5	7·6
Ash	1·8	1·6	1·8	1·9	1·8	1·9

It will be seen from these figures that the three specimens agree very closely in composition; the amount of caoutchouc in the dry material ranges from 80·1 to 82·6 per cent., whilst the percentages of the other constituents exhibit only slight variations. The amount of insoluble matter is rather high, although very little vegetable impurity was visible in the rubber.

The samples were valued at from 3*s.* 4*d.* to 3*s.* 9*d.* per lb. in London, with fine hard Para quoted at 4*s.* 2½*d.* per lb.

Conclusions.

The results of the examination of these specimens of *Mascarenhasia elastica* rubber from the East Africa Protectorate, Pemba, and Portuguese East Africa, show that the product is of good quality if carefully collected. No definite information is, however, available regarding the average yield of rubber which the trees will furnish, so that it is not possible at present to state the probable value of the plant as a source of rubber. The experiments which are in progress in all three countries will determine this point and also the further question of the suitability of this East African rubber tree for cultivation in suitable localities.

MISCELLANEOUS RUBBERS.

BITINGA RUBBER (*Raphionacme utilis*) FROM PORTUGUESE WEST AFRICA (1908).

Considerable interest has been aroused recently by the discovery in Portuguese West Africa of a plant, bearing various native names, such as "bitinga," "ecanda," and "marianga," the tuberous roots of which contain a rubber-yielding latex.

Several specimens of the rubber and of the roots of the plant from which it is obtained have been received at the Imperial Institute from the Mozambique Company, and the results of their examination are of some general interest.

Rubber.

The samples of rubber consisted of three roughly cylindrical pieces, which differed considerably in quality owing to the inclusion of varying amounts of impurities. The cleanest specimen, which, however, contained an appreciable amount of impurity, consisted of pale yellowish-brown rubber exhibiting good elasticity and tenacity. The other two pieces were darker in colour; one of them contained a considerable quantity of vegetable impurity, whilst the other was impregnated with fine sand. In both cases, however, the physical properties of the rubber were fairly good.

The light-coloured rubber was chosen for analysis as more likely to represent a well-prepared product, and this gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	1·0	—
Caoutchouc	76·8	77·6
Resin	9·0	9·1
Proteid	0·6	0·6
Insoluble matter ...	12·6	12·7
Ash	7·11	7·18

These results indicate that the rubber would be of good quality, so far as chemical composition is concerned, if it were not for the presence of the large amount of insoluble impurity which considerably reduces the percentage of true caoutchouc. The amount of resin is somewhat high, but the percentage of proteid is exceptionally low.

A portion of this sample was valued by commercial experts at 1*s*. to 1*s*. 3*d*. per lb., but they stated that the rubber, if clean, should be worth 3*s*. per lb., or more, with fine hard Para rubber at 4*s*. 10*d*. per lb. on the same date.

Roots.

A number of the tuberous roots of the plant were also received and submitted to examination. The tubers were turnip-shaped, and varied up to 5·5 inches in diameter and 4 inches in height. They were covered with a dark brown scaly bark. Many of the

roots had decomposed more or less during transit, but a number were still sound, and yielded latex quite freely on incision.

Two samples of the fresher roots with unbroken bark were selected for analysis; specimen A was a single large tuber weighing about 6 oz., whilst B consisted of two smaller tubers which together were approximately equal in weight to A.

The results of the examination were as follows:—

	A.	B.
	Calculated on roots as received.	
Moisture	86·88	88·87
Rubber	1·52	1·04
Insoluble residue, resin and other extractive matter	11·60	10·09
Rubber (on dry roots)	11·6	9·3

The yield of rubber from the tubers as received is therefore very low (1·0 to 1·5 per cent.) owing to the large amount of water which they contain, and as these tubers must have dried considerably during transit, the freshly-collected roots will probably furnish much less than the figures recorded above. The average yield of rubber from the dry material is however fairly high, viz., 10·5 per cent.

Identification of the Bitinga Plant.

Specimens of the "Bitinga" roots were forwarded to Kew by the Mozambique Company with a view to the identification of the plant, and flowering specimens were obtained in March, 1908. The plant proved to be a new species of Raphionacme of the natural order Asclepiadaceæ and has been named *Raphionacme utilis*, Brown and Stapf. A full description of the plant, including figures, was given in the *Kew Bulletin* (1908, No. 5, p. 209).

It is probable that the Bitinga plant thus identified is identical with the "Ecanda" or "Marianga" plant discovered by Professor Geraldes, during a journey to the Upper Zambesi, in 1904-05. According to this author (*Revista Agronomica*, Vol. iii. Nos. 4 to 8; *Estudo sobre os latex borrachiferos*, p. 143), the Ecanda or Marianga plant occurs in the sandy treeless plains (*anharas*) of Bailunde and Bihé and on the sandy steppes between the rivers Quanza and Zambesi, at an altitude of 4,000 to 5,000 feet.

The natives in these districts prepare rubber from the roots by cutting them into slices, which are then spread on the ground and exposed to the sun, whereby the exuded latex is coagulated. The rubber thus formed is rolled into small cylindrical pieces, about 5 inches long and $\frac{3}{8}$ inch in diameter. The rubber so prepared is stated to be of good appearance, but it usually contains considerable quantities of earthy impurity; thus, one sample examined contained only 45·8 per cent. of true rubber, and 51·4 per cent. of impurities.

Professor Geraldes found that the most practicable method of obtaining rubber from the fresh roots was to cut them into pieces and subject the latter to pressure. In this way the latex, much

diluted with the sap of the roots, was obained. The yield of liquid on expression amounted to about 77 per cent. of the weight of fresh roots used. From this liquid, the rubber can be prepared either by heating it or by exposing it to the air. The maximum yield of rubber obtained by Professor Geraldes in his experiments was a little less than 0·5 per cent. from the fresh roots, which is less than half the amount found in the tubers received at the Imperial Institute.

It is impossible until further particulars are available to express any opinion regarding the probable value of the Bitinga plant as a commercial source of rubber. Definite information is required as to (1) the rate of growth of the plant; (2) the age at which the tubers can best be utilised for the preparation of rubber; (3) the weight of fresh roots which can be obtained per acre; (4) the average yield of rubber; and (5) the best method of obtaining the rubber from the roots. It is understood that the Mozambique Company is conducting experiments in East Africa in order to determine these points, and to ascertain whether the plant is likely to repay cultivation.

ROOTS OF *Raphionacme divaricata* FROM THE TRANSVAAL (1909).

Specimens of the roots of this plant were forwarded for examination to the Imperial Institute in order that their possible value as a source of rubber might be determined.

The specimens consisted of two tuberous roots, one of which weighed 10¾ lb. This root was turnip-shaped and was covered with a light brown, thin, parchment-like bark; internally it was moist and of the consistency of a potato. On the root being cut with a knife, drops of latex exuded from the cut surface.

The second root, which was much smaller, was nearly dry internally, and was more or less completely permeated with a green mould.

The larger root alone was examined chemically, with the following results:—

	Per cent.
Moisture	87·33
Caoutchouc	0·00066

This amount of caoutchouc is equivalent to a yield of 0·0052 per cent. from the dry material.

It is clear that if this root is a representative specimen there is no likelihood of utilising the plant as a source of rubber. The amount of caoutchouc which it contains is very much less than that furnished by the roots of the allied plant *Raphionacme utilis* from Portuguese West Africa.

"MULIYA" RUBBER (*Diplorhynchus* sp.) FROM RHODESIA (1910).

No. 1. "Muliya rubber." Weight, about 6 oz. The sample consisted of a lump of rather soft material, light brown externally and greyish-white within. It was very moist and contained a little vegetable impurity in the form of fragments of bark. The material was sticky and evidently of resinous composition; it exhibited very little elasticity or tenacity.

An analysis gave the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	25·5	—
Caoutchouc	21·9	29·4
Resin	45·2	60·7
Proteid	1·9	2·6
Insoluble matter ...	5·5	7·3
Ash	1·0	1·3

The material described in the above table as "caoutchouc" was left after extracting the resins with acetone; it consisted of a blackish, slightly sticky, rubber-like substance, which was fairly tenacious, but possessed little elasticity.

Material of this type would have very little, if any, commercial value.

No. 2. "Muliya rubber." No. 2. Weight, about 10 oz. The sample consisted of a lump of rather soft reddish-brown material, containing a considerable amount of fine fragments of bark to which the colour was probably due. The material was very moist and resinous; it resembled the preceding sample in physical properties, but was not quite so sticky.

An analysis furnished the following results:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	29·2	—
Caoutchouc	12·7	17·9
Resin	39·2	55·4
Proteid	2·9	4·1
Insoluble matter ...	16·0	22·6
Ash	0·7	1·0

The material left after extracting the resins with acetone, and described above as "caoutchouc," consisted of a reddish-brown material free from stickiness, but exhibiting poor physical properties. This sample of the product was not so well prepared as No. 1. It contained a much larger amount of vegetable impurity and less "caoutchouc."

Material of this type would have very little, if any, commercial value.

"Mtomoni" Rubber from Nyasaland (1904).

This material was prepared from the latex contained in the fruit of a tree, apparently belonging to the order Apocynaceæ, which was stated to be abundant all over the plains at an altitude of 2,000 feet, and to be known by the natives as "Mtomoni." It appears that the latex can only be obtained in quantity from the ripe fruits, as very little exudes on making incisions in the stem or branches. The product is said to be largely used by the natives as birdlime, and also for smearing on small baskets in order to render them waterproof.

Three balls of the material prepared by the natives were submitted for examination. They were dark brown throughout, and contained a considerable amount of vegetable débris. The material could be moulded in the fingers but was not sticky, and it exhibited only slight elasticity and tenacity.

The following results were obtained on analysis:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	3·0	—
Caoutchouc	22·2	22·9
Resin	54·7	56·4
Insoluble matter ...	20·1	20·7
Ash	3·8	3·9

The dry material therefore contained over 20 per cent. of insoluble matter and 56·4 per cent. of resin. The caoutchouc present was of rather poor quality.

A sample of the specially prepared material was also forwarded for comparison with the product obtained by the natives. This was almost black and quite free from vegetable impurities; it could be moulded in the fingers and exhibited little elasticity but very fair tenacity. The sample was insufficient for analysis.

Loranthus Rubber from Venezuela (1907).

"Venezuelan Loranthus rubber." Weight, 1 oz. The sample consisted of two pieces of rubber: (1) a thin strip 1 inch by 3 inches, with smooth surface, and (2) a thin flat cake with rough surface.

The rubber was fairly tenacious but exhibited little elasticity. The following results were obtained on analysis:—

	Rubber as received. Per cent.	Composition of dry rubber. Per cent.
Moisture	4·7	—
Caoutchouc	54·4	57·1
Resin	17·7	18·6
Proteid	4·1	4·3
Insoluble matter ...	19·1	20·0
Ash	1·70	1·78

This Loranthus rubber is of inferior quality on account of the high percentage of resin and the large amount of insoluble matter present. The sample was too small for trustworthy valuation.

Getah Jelutong (Pontianac) from Sarawak (1903).

This specimen of Getah Jelutong and samples of a mineral substance used in its preparation were forwarded from Sarawak, through His Majesty's Consul at Brunei, for examination in the Scientific and Technical Department of the Imperial Institute.

From the correspondence accompanying the samples it appeared that the mineral substance used in the preparation of the Getah

or Gutta is obtained from China, and is known to the Malays as "Menang Sayla," and to the Chinese as "Chio Koh." This substance is not employed in its natural condition, but is baked before use, being reduced thereby to a kind of feathery powder, and its addition is said to be essential to the preparation process. The latter is described as follows:—"It (the Getah) is taken from the Jelutong tree, and is obtained by barking the tree and then scraping off the gum as it exudes, and not by tapping, a process which is very destructive to the trees. The Getah must be prepared immediately, and this is done by first sprinkling a pint of kerosene oil in a tub, then a kerosene tin full of water is poured in and the same quantity of gum, to which is added a teaspoonful of the 'Menang Sayla,' and the whole is then well mixed and afterwards kneaded and rolled into large balls, in which form it is exported." The local value of the product was stated to be about 5 dols. per picul, and in Singapore from 7 to 8 dols. per picul.

Getah Jelutong is already well known in the European and American markets under the name of Pontianac, but its commercial utilisation is chiefly confined to the United States, which imports large quantities annually. The supply is obtained from Borneo and the Malay Peninsula, and is not restricted to Sarawak.

The specimen of the Getah Jelutong was a large cheese-shaped mass, of light brown colour externally, but quite white and of granular structure within; it was almost free from dirt or vegetable débris, but contained a considerable quantity of water, which exuded on pressure, and it had a distinct odour of kerosene; it was soft, could be easily worked in the fingers, and possessed very little tenacity. On exposing a piece to the air for some time, however, the outer portion hardened and became friable. When treated with hot water it formed a very soft mass, without becoming sticky, and could readily be moulded, but it did not harden on cooling, merely returning to its original form.

On chemical examination the material was found to contain:—

	Per cent.
Moisture	40·8
Ash	0·28

The dry material was entirely soluble in cold ether, but only partially soluble in alcohol. It did not contain any of the hydrocarbon "gutta," the characteristic constituent of true gutta percha, but the following substances were isolated from it:—

1. A small quantity of a sticky elastic substance, resembling caoutchouc in appearance and properties;
2. A large quantity of a white granular substance;
3. A very small quantity of a distinctly crystalline substance;

the two latter substances being dissolved by hot alcohol.

A comparative examination of a sample of commercial Pontianac gave almost identical results.

In appearance the Getah Jelutong resembles a poor quality of gutta percha, but its composition, as indicated above, would suggest that it is more closely allied to the inferior varieties of rubber.

Getah Jelutong or Pontianac, is usually stated to be obtained from *Dyera costulata*, a large tree which is fairly common through-

out the Malayan region, but it is probable that the material as met with in commerce is a mixture of guttas derived from different sources. It has been stated, in fact, that it is the custom of the natives to mix the latex of the Jelutong tree with that derived from different species of *Willughbeia*, which yield inferior rubbers.

The sample of Getah Jelutong from Sarawak was almost identical in appearance, composition, and properties with commercial samples of Pontianac, being remarkably free from admixture with vegetable or mineral impurities, and it would, no doubt, be suitable for any purpose for which the latter is employed. At present, however, the material is of relatively small commercial value.

Two specimens of the mineral substance used in the preparation of Getah Jelutong were supplied; one of the mineral as imported, the other of the material prepared for use by heating.

The mineral proved to be a specimen of the fibrous variety of gypsum, known as "satin spar" (hydrated calcium sulphate); it was white, translucent, crystalline, and massive.

The specimen which had been heated was white and opaque; it was non-crystalline, but retained the fibrous form of the mineral, and readily crumbled to powder in the fingers. It absorbed water, but did not set like plaster of Paris. It contained only 2·48 per cent. of water, so that in its preparation the gypsum had probably been heated to a high temperature, with the result that the product does not set when mixed with water.

PRODUCT RESEMBLING "PONTIANAC" FROM PATIALA, INDIA (1904).

This product was obtained from the forests of Patiala, but no information was supplied regarding the botanical source or method of preparation. The sample received for examination consisted of ten blocks, each measuring 6 by 3 by 2¼ inches, the total weight of which was about 15 lb. The blocks were light yellowish-brown externally, but were creamy-white within. The material showed a somewhat laminated structure, the outer layers being rather brittle, and, although hard in the mass, small pieces softened and could be moulded in the fingers; it was moist and had a slightly sour odour. In appearance and general properties the material was practically identical with commercial "Pontianac," a product obtained in the Malay Archipelago from *Dyera costulata* and other trees.

The chemical examination of the Patiala product gave the following results:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	54·5	—
Resin	36·6	80·4
Caoutchouc	7·6	16·7
Insoluble matter ...	1·3	2·9
Ash	0·94	2·06

The isolated caoutchouc exhibited little plasticity but fair tenacity.

The analysis shows that in chemical composition, as well as in appearance and properties, this material from Patiala corresponds closely with Pontianac, which, when dry, usually contains about 15 per cent. of rubber-like substance, and there is no doubt that it would be readily accepted as Pontianac in the market. Pontianac is largely employed in the United States at the present time as an ingredient in the mixtures used for the manufacture of low-grade rubber goods, and recently the material has been strongly recommended as deserving more extensive use in this country also.

The material from Patiala was submitted for valuation to brokers, who described it as fairly dry Pontianac of the usual quality. From its appearance they considered that consignments represented by the sample would probably realise about £20 per ton in the London market.

EUPHORBIA LATICES FROM NYASALAND (1904).

Three small bottles of Euphorbia latex were forwarded to the Imperial Institute from Nyasaland for examination, but in each case the liquid had coagulated during transit. They were labelled as follows:—

"No. 1. *Euphorbia Candelabrum.* Native name 'Ngwesa.'"

"No. 2. *Euphorbia* species. Native name 'Leukuta.'"

"No. 3. *Euphorbia* species. Native name 'Ngache.'"

No. 1. *Euphorbia Candelabrum*, "Ngwesa."

This material was a white curdy substance which weighed 14 grams. It was very resinous and friable.

No. 2. *Euphorbia* sp., "Leukuta."

The coagulated material weighed 18 grams after drying; it had a light green colour and was very friable.

No. 3. *Euphorbia* sp., "Ngache."

The coagulated material weighed only 3·5 grams after drying. It was a white friable substance.

The analysis of these three products gave the following results, which are expressed on the dry material for comparison:—

—	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Resin	63·4	71·8	70·8
Caoutchouc	23·9	23·3	19·1
Insoluble matter	12·7	4·9	10·1
Ash	3·1	4·1	4·5

These results show that the products consist principally of resin, the percentages of which range from 63·4 to 71·8, whereas the amount of caoutchouc (or caoutchouc-like material) present varied from 19·1 to 23·9 per cent. The substance isolated as caoutchouc from No. 1 was of very poor quality, possessing little elasticity or tenacity; that from No. 2 was fairly elastic when first prepared, but became hard and brittle on standing, so that it cannot be classed as true caoutchouc; the caoutchouc from No. 3 was much superior to that derived from Nos. 1 and 2.

Owing to the friable nature of these products when dry, it is very improbable that any of them could be utilised commercially.

EUPHORBIA LATICES FROM THE TRANSVAAL.

I. (1906).

Samples of the coagulated and uncoagulated latex of a Euphorbiaceous plant growing in the warmer parts of the Transvaal were forwarded for examination to the Imperial Institute by the Department of Agriculture at Pretoria. It had been suggested that the Transvaal tree is identical with the species of Euphorbia which yields the "Intisy" rubber of Madagascar, and it was consequently desired to ascertain whether the product was of commercial value.

Specimens of the plant had been sent to Kew for identification, but it was ascertained on inquiry from the Director of the Gardens that it had not been possible to determine accurately the identity of the tree from the material forwarded. The plant may be a species of Euphorbia allied to *Euphorbia mauritanica* and *Euphorbia Tirucalli*, but distinct from both. It may be mentioned that the "Intisy" rubber of Madagascar is derived from a species of Euphorbia which has been described as *Euphorbia Intisy*.

Coagulated Product.

The samples of the coagulated latex consisted of three large lumps, one of which was labelled: "Found and prepared by A. C. van Maarseveen, of Potgietersrust, mixed with a few drops of sour lemon juice and boiled until coagulated. Fairly clean. 27/2/06." This sample weighed 15 oz.; it is referred to below in the table of analyses as Sample A.

The two other pieces were unlabelled, and together weighed 2¼ lb. They were identical in apparance, and were treated as one sample—referred to as B—in the analytical results.

The material was hard, and was evidently of resinous character; it had a slight yellow colour and possessed a disagreeable odour. In appearance it resembled the product known as "Almeidina," which is obtained in West Africa from a species of Euphorbia usually described as *Euphorbia rhipsaloides*, Welw.

The chemical examination gave the following percentage results:—

—	Material as received.		Composition of dry material.	
	A.	B.	A.	B.
Moisture	28·9	27·9	—	—
Resin	55·8	54·6	78·5	75·7
Caoutchouc	13·8	15·0	19·4	20·8
Proteid	0·5	0·4	0·7	0·6
Insoluble matter ...	1·0	2·1	1·4	2·9
Ash	2·33	2·30	3·28	3·19

These results show that the product is of very resinous character, the dry material in each case containing over 75 per cent. of resin. The substance returned as caoutchouc was, moreover, totally unlike true rubber in properties, and on drying it became quite friable.

Latex.

The two samples of latex were labelled I. and II. Sample I. consisted of 300 c.c. of a thin yellowish-white latex, and was stated to have been obtained from a single tree in three-quarters of an hour. Sample II. consisted of the same quantity of similar latex, which was obtained from two trees younger than that which yielded No. I.; the quantity of latex represented, it was said, about three-fourths of that obtained in half an hour.

Both latices were readily coagulated in the cold by the addition of a little alcohol. The addition of acids had little influence until the latex was warmed, when coagulation occurred—immediately if a dilute mineral acid was used, and slowly in the case of acetic and citric acids. The solid products prepared by these methods were exactly similar to the samples sent from the Transvaal.

Latex No. I. furnished about 34 per cent. of dry coagulum, whereas the yield from No. II. was almost 50 per cent.

Analyses of the dry coagulated products gave the following results:—

	I.	II.
Resin	85·0	92·8
Caoutchouc	14·4	6·7
Proteid	0·6	0·3
Ash	—	0·2

The product prepared from Latex No. I. corresponds generally in composition with the coagulated material sent from the Transvaal, but contains a little more resin. The other sample, No. II., yielded a still more resinous product, but this is no doubt explained by the fact that the latex was obtained from young trees, in which, as a rule, the percentage of resin is higher than in older plants.

Commercial Value.

Samples of the solid material were submitted for valuation to brokers, who described it as "Almeidina" of fair ordinary quality, and valued it at 8*d.* *to* 10*d.* per lb. in London. They added, however, that there is only a very moderate demand for such material here.

Conclusions.

The investigation has shown that this species of Euphorbia growing in the Transvaal does not furnish a rubber-like product resembling that derived from *Euphorbia Intisy* in Madagascar, but a resinous material very similar to the "Almeidina" from West Africa. In view of the limited demand for almeidina, it is doubtful whether the price quoted would make the collection of the product remunerative in the Transvaal, but this is a point for local consideration.

II. (1907).

This sample of latex, stated to be derived from a Euphorbiaceous tree called "Mutlalamela" by the natives in the Transvaal, was forwarded for examination to the Imperial Institute by the Director of Agriculture at Pretoria.

The latex had partly coagulated during transit. The fluid portion had a slight acid reaction, and could be coagulated by the addition of glacial acetic acid, but not by dilute acetic or mineral acids; alcohol or acetone caused immediate coagulation.

A quantity of the latex was coagulated by the addition of acetone, and after drying for three days in the air the resulting product was analysed. It had the following composition:—

	Per cent.
Moisture	19·5
Resin	61·5
"Caoutchouc"	15·9
Proteid	0·5
Insoluble matter	2·6

The material is therefore of very resinous character, and the constituent returned as "caoutchouc" did not exhibit the characters of true rubber, but became friable on drying.

This material is very similar in composition and properties to the specimens of a product derived from another Euphorbia in the Transvaal, which are dealt with in the preceding report. It could probably be sold as "Almeidina," the current value of which in this country is 50*s.* per cwt.

Euphorbia "Rubber" from Natal (1907).

Two products stated to have been derived from the latex of species of Euphorbia growing in Natal were submitted to the Imperial Institute for examination.

No. 1. "From the large tree Euphorbia" (weight 3 oz.).—A hard resinous substance of pale yellow colour; it had a disagreeable odour, and contained a quantity of vegetable impurity. When placed in warm water it softened and became plastic and slightly elastic, but hardened again on cooling.

No. 2. "From a small species of tree Euphorbia" (weight 3 oz.).—This material was of similar character to No. 1, but was white, and not quite so hard. It softened and became plastic when warmed, but was not so elastic as No. 1, and remained slightly plastic on cooling.

A chemical examination of the two products gave the following results:—

	No. 1. Per cent.	No. 2. Per cent.
Moisture	16·2	13·4
"Caoutchouc" ...	17·3	15·9
Resin	60·4	66·5
Proteid	1·5	1·5
Insoluble matter ...	4·6	2·7
Ash	3·15	1·97

The two products are very similar in composition and are of resinous character. The substance returned as "caoutchouc" in the analytical results possessed none of the properties of true rubber.

These products resemble the "Almeidina" of commerce in composition and properties, and could probably be utilised for the same purposes.

"Rubber" from Southern Rhodesia (1906).

This sample of rubber-like material was forwarded from the Agricultural Department at Salisbury, Southern Rhodesia, but no information was supplied regarding its botanical origin.

The material was in the form of a thick cake, which weighed 1½ oz. It was black externally and dark grey within, but the freshly-cut surface soon blackened on exposure to air. It had a disagreeable odour, and contained a considerable quantity of impurity in the form of grain husks. Its physical characters showed little resemblance to true rubber, as it was sticky and exhibited little elasticity and tenacity.

The material was analysed and furnished the following results:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	34·6	—
Resin	36·7	56·1
"Caoutchouc" ..	21·0	32·1
Proteid	1·6	2·4
Insoluble matter ...	6·1	9·3
Ash	4·62	7·06

It will be seen from these figures that the material is of very resinous character, over 56 per cent. of resin and 32 per cent. of "caoutchouc" being present in the dry material. The substance returned as "caoutchouc" was of very inferior quality and exhibited little elasticity or tenacity; it was, in fact, unlike true rubber either in appearance or properties.

It is evident from these results that this product from Southern Rhodesia is of very inferior quality, and that it would not be suitable for technical use as rubber. It might be possible to utilise it for certain purposes for which Pontianac, Almeidina and other similar products are now employed, but it would only fetch a very low price in the market, and it is doubtful whether its collection in Southern Rhodesia would prove remunerative.

"Gutta Percha" from Southern Rhodesia (1907).

This sample of so-called "gutta percha" was obtained from Lomagundi, Southern Rhodesia

The sample, which weighed about 1 oz., consisted of a cream-coloured substance which was rather friable and evidently of resinous nature. It became soft and plastic on immersion in hot water, but hardened again on cooling.

The sample was too small for complete chemical examination, but the following determinations were made:—

	Material as received. Per cent.	Composition of dry material. Per cent.
Moisture	37·5	—
Resin	44·6	71·4
Insoluble matter ...	3·5	5·6
Ash	3·0	4·8

The results show that the material is of very resinous character. It was found to contain no gutta, the characteristic constituent of gutta percha, but a small amount of inferior rubber-like substance was present.

The material therefore resembles the Almeidina of commerce, and could possibly be utilised for the same purposes. It would be quite useless as a substitute for gutta percha.

A much larger sample would be required for commercial valuation, but it may be stated that the present value of Almeidina is about 50*s*. per cwt. in London, and this product from Southern Rhodesia would not realise more than this price.

No information was supplied regarding the botanical source of the material, but, like Almeidina, it may be derived from a Euphorbiaceous tree.

"Almeidina" from Southern Nigeria (1905).

This sample of material was described as "Almeidina," but no information was supplied regarding the botanical source of the product.

The specimen consisted of a single cake, weighing 14½ ozs., which was light brown externally and whitish within. The material was hard and slightly sticky; it exhibited no elasticity and only feeble tenacity, and was evidently of resinous nature.

On analysis it gave the following results:—

	Per cent.
Moisture	7·0
Resin	67·6
Caoutchouc	23·6
Insoluble matter	1·8
Ash	1·3

The material therefore consists principally of resins, and the isolated caoutchouc was only of poor quality.

In appearance, composition and general properties this material from Southern Nigeria somewhat resembles the product exported from Portuguese West Africa under the name of "Almeidina" or "Potato gum," and could no doubt be sold as such. The normal price of this product in the London market is about 3*d*. per lb., and as there is only a limited demand it is usually slow of sale. Recently, however, there has been a scarcity of this material in the market, and holders of stocks have been asking 6*d*. per lb. The former price, viz., about 3*d*. per lb., is probably all that a large consignment of this product from Southern Nigeria would realise, and it is a question for local consideration whether such a price would be remunerative.

GUTTA PERCHA AND BALATA.

GUTTA PERCHA.

Gutta percha is obtained from a number of species of Palaquium, belonging to the natural order Sapotaceae, which are natives of the southern portion of the Malay Peninsula, Sumatra, Banca, Borneo, Celebes, the Sulu Islands, and the Philippines. The trees are not indigenous in Java, but have been introduced into that island.

The best quality of gutta percha is furnished by *Palaquium Gutta*, *P. oblongifolium*, and *P. borneense*. The second of these, *P. oblongifolium*, is considered by many botanists to be only a variety of *P. Gutta* and not a distinct species. Other species of Palaquium and Payena furnish gutta percha of second quality. Until recently there has been considerable confusion regarding the botanical identity of many of the trees yielding gutta percha, owing to the difficulty of obtaining authentic flowering specimens, and to the fact that in the different districts of the Malay Peninsula the same native names are applied to distinct species.

Palaquium Gutta, which may be regarded as the principal source of gutta percha, is a large forest tree with a straight cylindrical trunk. Specimens up to 150 feet in height and 4 to 5 feet in diameter have been recorded. The tree is easily recognisable in the forest by its leaves which are coppery gold colour on the under surface and dark glossy green on the upper. In a mature tree the leaves are about 2 inches long, but they are much longer in the young plants.

The natives obtain the gutta percha by felling the trees and making incisions right round the trunk at distances of 9 to 12 inches or even less. The latex either coagulates spontaneously in the cuts and is scraped off, or it is collected in vessels placed underneath, and is subsequently coagulated by boiling. The gutta percha thus obtained is afterwards softened in warm water and made up into blocks of various sizes. The yield of gutta percha obtained from a mature tree by this process varies very considerably, but is usually not more than 1 lb.; cases are however recorded of very large trees which have furnished as much as 8½ lb. of gutta percha when felled.

The native method of obtaining gutta percha has resulted in the destruction of large numbers of the trees, and in the Federated Malay States it has been necessary recently to adopt measures for the protection of the existing trees, and for planting them in suitable districts. Plantations of the trees have also been formed in Java. Attempts are being made to obtain the gutta percha by tapping the standing trees instead of felling them, and also to extract by mechanical processes the gutta percha present in the leaves of the plant.

BALATA.

Balata is the product obtained on coagulating the latex of *Mimusops globosa*, Gaertn., a large tree belonging to the natural order Sapotaceæ which is a native of British, French and Dutch Guiana, Venezuela, Brazil, Trinidad, and Jamaica. In British Guiana and the West Indies the tree is known as the Bully or

Bullet tree. Balata resembles gutta percha in composition and properties, and is the best natural substitute for the latter product.

The trees are tapped by making zig-zag incisions in the bark which are so arranged that the latex flows from one to the other down to the base of the trunk. It is then either poured into shallow wooden vessels and allowed to coagulate spontaneously when sheet balata is formed, or it is coagulated by boiling and the balata made into lumps. The product varies in colour from grey to pinkish-brown. The yield varies but it is stated to average about 5 lb. of dry balata per tree in British Guiana.

A number of other species of Mimusops furnish products resembling balata, but much inferior in quality.

GUTTA PERCHAS FROM THE STRAITS SETTLEMENTS (1904).

These samples of gutta percha were forwarded from Penang for the purpose of ascertaining their chemical composition and commercial value.

The specimens received were as follows:—

1. Sample of gutta percha and about 50 lb. of dried leaves of the species of Palaquium (*Palaquium pustulatum?*) known in the State of Perak as "Gutta Taban Putih."

2. Sample of "Gutta Simpor" (*Palaquium Maingayi*).

3. Sample of "Gutta Taban Chaia" (*Palaquium polyanthum?*).

4. Sample of "Gutta Minjato" (*Bassia* sp.?) from Langkawi Islands.

5. Sample of "Gutta Susu" (*Dyera* sp.) from Langkawi Islands.

6. "Gutta Taban Merah" (*Palaquium Gutta*) from Penang forests.

The specimens Nos. 1, 2, 3, and 6 were collected under the supervision of European forest officers in order to ensure their authenticity, and they therefore represent the products of the different species of Palaquium without any admixture whatsoever.

Information was particularly desired concerning specimens Nos. 1 to 5, and of these, No. 1, Gutta Taban Putih, was stated to be the most important. This gutta is derived from a tree, probably *Palaquium pustulatum*, though the species is a little uncertain at present, which is the most abundant of the Palaquiums in the State of Perak, as it will grow at elevations of over 2,000 feet. If the gutta percha yielded by this species proved to be of good quality it was proposed to establish extensive plantations of the trees.

Numerous proposals have been made during recent years to extract the gutta percha from the leaves of the Palaquiums, thereby obtaining an earlier yield from the plantations than would be possible otherwise. A large sample of the dried leaves of the tree yielding the Gutta Taban Putih was forwarded, therefore, so that experiments could be made to determine the amount and quality of the gutta percha contained in them, and the feasibility of extracting it upon a commercial scale.

The leaves were found to contain about 2 per cent. of pure gutta, equivalent to a yield of 5·6 per cent. of gutta percha of similar composition to the sample of Gutta Taban Putih submitted for examination. The average yield of gutta percha obtainable from the fresh leaves will, however, have to be determined by experiments conducted on the spot.

The processes which have been employed for extracting gutta percha from leaves by means of solvents do not appear to have been a commercial success, and it seems probable that a mechanical process would give better results, especially if the fresh leaves are to be treated in the tropics. A process depending upon the digestion and agitation of the crushed leaves with hot water in suitable machines may be suggested for experimental trial. The gutta percha in fresh leaves could possibly be readily separated by such treatment and could be easily washed free from vegetable impurities. A method of this kind, if successful, would be much preferable to, and cheaper than, any process involving the use of solvents.

In view, however, of the great superiority of Gutta Taban Merah over the other varieties of gutta percha, it would be desirable in any experiments on the subject to use the leaves of that tree, as they would in all probability furnish the best results.

Description of Samples.

No. 1. Gutta Taban Putih, from *Palaquium pustulatum?*

The specimen was a conical mass which varied from brown to bluish-black externally, but when freshly cut it was almost white within. It was hard, very tenacious, and contained very little foreign matter. On immersion in hot water it softened, becoming plastic, but not sticky, and could be readily moulded, after which treatment it returned to its original condition on standing.

No. 2. Gutta Simpor, from *Palaquium Maingayi*. This was a rounded cake, light brown externally, but whitish within, which had a distinct cinnamon odour, and contained a small amount of foreign vegetable matter. It was hard in the mass, but the inner portions were easily friable, whereas the outer layers were tougher and somewhat laminated; the greater part of the sample was easily reduced to coarse powder in a mortar. It became plastic, but not sticky, when immersed in hot water, and the water acquired a slight yellow colour. After this treatment it hardened somewhat on standing, but exhibited little tenacity, readily breaking when bent.

No. 3. Gutta Taban Chaia, from *Palaquium polyanthum?*

The specimen was a small rounded mass, which was brown externally but much lighter within, and contained a small quantity of vegetable matter. It was hard in the mass, and exhibited considerable tenacity; small pieces were slightly elastic, and softened a little when held in the hand. When placed in hot water it behaved exactly like the preceding specimen, but exhibited much greater tenacity after cooling.

No. 4. Gutta Minjato, from *Bassia* sp? From the Langkawi Islands.

The sample was a rectangular cake, dark brown externally, but light brown within, which exhibited a laminated appearance when

cut, and contained a slight amount of vegetable matter. It was hard in the mass, but fragments were easily friable, and it could be reduced to coarse powder in a mortar. When treated with hot water it formed a very soft, sticky mass, and communicated a slight yellow colour to the water. After this treatment it remained flexible for some time but finally became hard and brittle, breaking readily with a short fracture.

No. 5. Gutta Susu, from *Dyera* sp. From the Langkawi Islands.

This was a flat rounded cake, dirty white externally, but quite white within, and almost entirely free from extraneous vegetable matter. It is probably identical with commercial "Pontianac," which it closely resembles in appearance. The sample was fairly hard in the mass, but small pieces could be moulded in the fingers becoming slightly sticky. On immersion in hot water it softened, becoming quite plastic and rather sticky, and only hardened a little on standing.

No. 6. Gutta Taban Merah, from *Palaquium Gutta*. From Penang forests.

This was a rounded mass which presented a mottled appearance, the colour varying from light brown to nearly white. A fair amount of vegetable matter was present, chiefly small pieces of bark. The material was very hard and tenacious. It softened in hot water, becoming quite plastic, but not at all sticky, and regained its original condition on standing.

Results of Examination.

The samples were submitted to chemical examination with the following results:—

No	Variety of Gutta Percha. Native Name and Botanical Source.	Moisture.	Gutta.	Resin.	'Dirt' and Insoluble Matter.	Ash (included in dirt).	Character of Gutta.	Character of Resin.
		Per cent.	Per cent.	Per cent.	Per cent	Per cent.		
1	Gutta Taban Putih ... *Palaquium pustulatum?*	7·5	35·6	49·5	7·4	0·72	Light brown, strong.	White, hard.
2	Gutta Simpor ... *Palaquium Maingayi.*	1·2	44·9	45·5	8·4	2·13	" "	" "
3	Gutta Taban Chaia *Palaquium polyanthum?*	1·2	52·0	43·4	3·4	1·61	Light brown, rather better quality than Nos. 1 and 2.	Yellowish-brown, hard and translucent.
4	Gutta Minjato ... *Bassia* sp.?	2·6	22·4	70·1	4·9	0·66	Light brown, friable and somewhat waxy.	Yellowish-brown, hard and translucent.
5	Gutta Susu ... *Dyera* sp.	19·5	1·9	69·8	8·8	0·71	Contained no true gutta	White, soft.
6	Gutta Taban Merah *Palaquium Gutta*	10·2	68·3	13·4	8·1	0·89	Light colour, strong, excellent quality.	Yellowish-white, soft.

For comparison, the percentages of gutta, resin, and dirt have been calculated for the dry material as follows:—

—	No. 1. Gutta Taban Putih.	No. 2. Gutta Simpor.	No. 3. Gutta Taban Chaia.	No. 4. Gutta Minjato.	No. 5. Gutta Susu.	No. 6. Gutta Taban Merah.
Gutta	38·5	45·5	52·6	23·0	2·4	76·0
Resin	53·5	46·0	44·0	72·0	86·7	15·0
Dirt and insoluble matter.	8·0	8·5	3·4	5·0	10·9	9·0
Ash (included in dirt)	0·77	2·16	1·64	0·7	0·9	1·0

These results show that the sample of Gutta Taban Merah, No. 6, which represents the highest class of gutta percha, is of excellent quality, and far superior to any of the other specimens. The Gutta Taban Putih, No. 1, contains a much higher percentage of resin, and is, therefore, very inferior in quality to No. 6; the gutta which it contains is however strong, and of good quality. Gutta Simpor, No. 2, is also an inferior grade of gutta percha, owing to the presence of much resin, but here again the actual gutta is of good quality. The Gutta Taban Chaia, No. 3, is a very similar material to Nos. 1 and 2, but contains a little less resin, and its gutta is of rather better quality. The Gutta Minjato, No. 4, and Gutta Susu, No. 5, are not true gutta perchas, since they contain no proper gutta. The "gutta" obtained from No. 4 was a friable and somewhat waxy substance, possessing little or no strength, whilst No. 5, which resembles Pontianac, contained no gutta, but a quantity of rubber-like material, which was completely dissolved with the resin on treatment with ether. Neither of these samples could be utilised for insulating purposes.

For comparison with the foregoing results, some analyses by Dr. Obach of similar samples of gutta percha of known botanical origin may be quoted (*see* Journal of the Society of Arts, Vol. XLVI., pp. 125 and 127).

Specimens of Gutta Percha collected in Perak by Mr. Leonard Wray, junr., and presented to the Royal Botanic Gardens, Kew, in 1883–4. (Analysed in 1885.)

Variety of Gutta percha. Native Name.	Botanical Source given by Mr. Wray.	Appearance.	Water.	Gutta.	Resin.	Dirt.	Character of Gutta.	Character of Resin.
			Per cent.	Per cent.	Per cent.	Per cent.		
Getah Taban Puteh (white).	*Dichopsis polyantha* (Benth.).	White, clean ...	1·0	47·0	48·4	3·6	Light brown, elastic.	Light brown, brittle.
Getah Taban Simpor ...	*Dichopsis Maingayi* (Clarke).	Nearly white, clean, crumbly	1·2	23·1	71·5	4·2	Light pinkish-brown, elastic	Very light, hard.
Getah Taban Chaier (liquid).	*Dichopsis pustulata* (Hemsley).	White, dense, clean.	1·7	45·3	49·6	3·4	Light brown, elastic.	Light brown, very brittle.
Getah Taban Merah (red)	*Dichopsis Gutta* (Benth. and Hook.).	Very light, pinkish, clean.	1·4	77·1	16·9	4·6	Light pinkish, elastic, prime	Brownish yellow, very hard.

A second and larger sample of Getah Taban Simpor from *Dichopsis Maingayi* was sent to Kew by Mr. Wray in 1886. On analysis this was found to contain 31·2 per cent. of gutta and 62·3 per cent. of resin, and was, therefore, of better quality than the first specimen.

Specimen of Gutta Percha obtained by Dr. Obach from Mr. H. N. Ridley in 1892.

Getah Taban Merah ...	*Dichopsis Gutta* (Benth.).	Light pinkish-brown, clean, dense.	13·1	66·7	14·0	6·2	Light pinkish, very strong.	Hard, reddish brown, translucent.

The results of the chemical examination of the present series of samples are in general agreement with the previous analyses just given. The sample of Gutta Taban Putih analysed by Dr. Obach was of rather better quality than that now under notice, whereas the present samples of Gutta Simpor and Gutta Taban Chaia are distinctly better than the earlier specimens. It will be noticed that the botanical sources of Gutta Taban Putih and Gutta Taban Chaia are transposed in the two series.

Commercial Value.

The samples were submitted for valuation and technical trial to manufacturers using large quantities of gutta percha, who reported that, as the result of their examination, they valued the specimens as follows:—

No. 1, Gutta Taban Putih, 2*s.* per lb.
No. 2, Gutta Simpor, 1*s.* 6*d.* per lb.
No. 3, Gutta Taban Chaia, 2*s.* 4*d.* per lb.
No. 4, Gutta Minjato, no use for insulating purposes.
No. 5, Gutta Susu, no use for insulating purposes.
No. 6, Gutta Taban Merah, 6*s.* per lb.

The price of the last sample may be taken to represent the market value of the highest grade of gutta percha, subject to fluctuations, and it is evident, therefore, that Gutta Taban Putih of similar quality to the present specimen will only command one-third the price of this. It will be noticed, too, that a higher value is assigned to the Gutta Taban Chaia than to the Gutta Taban Putih. The Gutta Susu would fetch the market price of Poutianac.

Conclusions.

This enquiry has shown, therefore, that the Gutta Taban Putih is very inferior in quality to the Gutta Taban Merah, and that it is only worth about one-third the price of the latter. No information has been furnished regarding the relative yields of gutta percha obtained from the two trees in these experiments, but previous investigations upon this point seem to indicate that there is no great difference in this respect between the two species. If this be so, the establishment of extensive plantations of the trees yielding Gutta Taban Putih could not be recommended in any locality where the much more valuable Taban Merah trees can be successfully grown, as there can be no doubt that the latter would give the best financial results. If the Taban Putih trees can be grown at higher altitudes than the other species, it would probably be advantageous to establish supplementary plantations of them in suitable districts. The trees yielding Gutta Taban Chaia may also be worthy of further experiments if they are suitable for cultivation in any districts where Taban Merah trees cannot be grown, since the gutta percha furnished by them appears to be slightly superior to the Gutta Taban Putih.

GUTTA PERCHA FROM FEDERATED MALAY STATES (1907).

This sample of gutta percha from Perak was stated to have been obtained by tapping the standing trees and to represent the pure product furnished by *Palaquium Gutta.*

The sample weighed about 4½ lb., and consisted of a number of somewhat flattened balls of different sizes. The balls presented a mottled appearance, the colour varying from dirty white to pale brown; most of them were white internally, but a few were reddish-brown. The gutta percha appeared to be free from extraneous vegetable matter. It was tenacious and very hard, but softened in hot water, becoming plastic but not sticky, and regained its original condition on cooling.

A representative sample selected from several balls was analysed with the following results:—

	Gutta percha as received. Per cent.	Composition of dry gutta percha. Per cent.
Moisture	14·8	—
Gutta	70·1	82·3
Resin	13·9	16·3
Proteid	0·5	0·6
Insoluble matter ...	0·7	0·8
Ash	0·95	1·1

These results show that the material is of excellent quality and contains a higher percentage of gutta than is usually found in the better grades of gutta percha which appear in commerce.

In accordance with the request of the Conservator of Forests a sample of the gutta percha was forwarded to a firm of manufacturers for technical trial and valuation. After submitting the material to tests the firm reported that it appeared to be of very good quality and exceptionally free from dirt and water. The loss on washing was consequently only small, but it was considered doubtful whether commercial consignments could be obtained equal in this respect to the small sample. The value of a consignment of gutta percha of similar quality to the sample submitted was given by the firm as between 8*s.* and 9*s.* per lb. in London.

Gutta of *Palaquium petiolare* from Ceylon (1903).

These samples of gutta were stated to have been collected from one species of tree only, viz., *Palaquium petiolare*, Engl., growing at Hinidoon Kanda, South-West Ceylon. Three distinct samples, prepared by different methods, were submitted:—

No. 1. "20 balls, each prepared by rubbing the latex in palm of hand."

No. 2. "1 ball prepared by rubbing in palm of hand after the greater part of the water had been driven off by slow heating for two hours."

No. 3. "Thin layers prepared by evaporation at ordinary temperature of air. Exposed to air for over three months."

Description of Samples.

No. 1. The balls ranged from 1 to 2 inches in diameter and had a smooth shining surface; externally the colour varied from

yellowish-white to brown, but internally the freshly broken surface was milk-white, turning yellowish-white on exposure to the air; the fracture was smooth and the balls was quite free from foreign vegetable matter; when whole they had no odour, but when freshly broken a slight sour smell was noticed. The balls were fairly hard and withstood a sharp blow without fracture, but small pieces were rather friable and showed no toughness; the material was easily reduced to a coarse powder in a mortar. On holding a piece in the hand it softened so that it could be moulded, and on immersion in hot water it became very sticky and plastic; after the latter treatment the mass took some time to harden, and at the end of two days it was still fairly flexible.

No. 2. The ball was about 2 inches in diameter and was almost identical in appearance and properties with sample No. 1. The only differences noticed were that on standing exposed to the air it developed a slight reddish tinge, which was afterwards lost as it gradually darkened, and that after softening in water it took longer to harden.

No. 3. This was an aggregated mass formed of thin plates of the gutta which had adhered together; these were dark brown in colour externally but nearly white within. The plates were brittle, breaking easily with a smooth fracture, but when held in the hand they softened so that they could be bent without breaking, and finally could be moulded in the fingers. In other respects it resembled sample No. 1, but took longer to harden after immersion in hot water.

Results of Examination.

The three samples as received had the following composition:—

—	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Moisture	9·6	5·0	1·3
Resin	62·3	68·6	68·0
Gutta ?...	24·6	25·0	25·1
Dirt	3·5	1·4	5·6
Ash (included in dirt) ...	1·05	0·65	1·25

For purposes of comparison the percentages of resin, gutta and dirt may be expressed on the dry material as follows:—

—	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Resin	68·9	72·2	68·9
Gutta ?...	27·2	26·3	25·5
Dirt	3·9	1·5	5·6

These results show that the samples are very uniform in composition, the only considerable variation being in the amount of insoluble matter (dirt) present. Sample No. 2, which had been prepared by heating, contained the largest amount of resin, but otherwise the different methods of preparation had apparently little influence upon the composition of the product.

It was clear from the physical properties of the samples that the gutta percha is of inferior quality, and this opinion was confirmed by the large percentage of resinous substances found on analysis. Moreover, the "gutta" obtained from it did not exhibit the characteristic properties of the substance from true gutta percha, being friable, devoid of strength, and softening when held in the fingers. In fact no true gutta was present in any of the samples.

Material of this character possesses no value for insulating purposes, and the brokers to whom it was submitted for commercial valuation stated that it would only be worth about 1½*d.* per lb.

SEYCHELLES.

"*Gutta percha*" *from the Capucin tree,* Northea seychellana (1904).

The Capucin tree, *Northea seychellana*, is a member of the natural order Sapotaceæ, to which the trees yielding true gutta percha (*Palaquium Gutta*, etc.) also belong. Its latex is said to flow freely on tapping.

The two samples of the product had been prepared in different ways, one by heating the latex at 100° C., and the other by evaporating it to dryness in a cool place.

No. 1. "Capucin milk coagulated by heating at 100° C."

The sample consisted of two circular cakes, each about three inches in diameter and one-eight of an inch thick, which together weighed 33 grams. The material somewhat resembled gutta percha in appearance and properties. It was greyish-white, fairly hard and inelastic in the mass; it possessed a slightly fibrous structure but exhibited little tenacity, the cakes breaking easily with an irregular fracture. Small pieces softened and could be moulded when held in the fingers. When treated with hot water the material become soft and sticky, but hardened again on standing.

No. 2. "Capucin milk coagulated by evaporation to dryness, temperature 24° C."

This was a single cake, weighing 103 grams, which was light-brown externally but greyish-white within. It showed a laminated structure, and was much more brittle than the preceding specimen, with which it otherwise agreed in properties.

A preliminary chemical examination showed that these products from the Capucin tree are more closely related in composition to gutta percha than to rubber, as they contain no caoutchouc but a substance similar in character and properties to gutta, the characteristic constituent of true gutta percha. The following figures were obtained on analysis:—

—	Material as received.		Composition of dry material.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	3·1	12·5	—	—
Resin	67·4	55·6	69·5	63·5
Gutta	20·1	10·2	20·8	11·7
Insoluble matter	9·4	21·7	9·7	24·8
Ash	7·5	8·2	7·7	9·4

These results show that the material is largely composed of resins, and that only small amounts of the gutta are present. The gutta is of inferior quality to that obtained from true gutta percha, being very deficient in strength. It is noteworthy that almost the whole of the ash from both specimens consisted of lime. Material of this character would have little commercial value.

Balata from British Guiana (1908).

Specimens of balata and of the latex of the "Bastard Bullet" tree from British Guiana have been received at the Imperial Institute for examination.

The balata was described as a very fine specimen of the product, and was of guaranteed purity. It consisted of a sheet of balata from $\frac{1}{8}$ to $\frac{3}{8}$ inch thick, which was pale reddish-brown, free from impurities, and evidently of very good quality.

It had the following composition:—

	Balata as received Per cent.	Composition of dry balata. Per cent.
Moisture	1·9	—
Gutta	49·7	50·7
Resin	44·0	44·8
Proteid	3·8	3·9
Ash	0·6	0·6

The results of the analysis show that the balata is of very good quality, the percentage of gutta being higher than that usually found in commercial consignments of the product. It was valued at 2*s.* 2½*d.* per lb. in London.

The latex of the "Bastard Bullet" tree was also examined in order to determine the nature of the material which it furnishes. On heating the latex it gradually thickened, becoming semi-solid, and on standing the mass slowly solidified. The product thus obtained was a pink brittle substance, quite devoid of tenacity, and evidently of very resinous character. The diluted latex was readily coagulated by the addition of alcohol, and a quantity of the material was prepared in this way for examination.

The analysis of the dry substance gave the following results:—

	Per cent.
Resin	70·6
Ash	6·7

The residue left after the extraction of the resin was a white friable powder, quite unlike the gutta of true balata.

It is evident from these results that the product from the "Bastard Bullet" tree is a resinous material differing widely in composition and properties from true balata. In consequence, the inclusion of the latex of this tree when collecting balata should be avoided.

Balata from Venezuela.

Balata (*Mimusops globosa*) from Venezuela (1907).

A block of balata measuring about 8 inches × $3\frac{1}{2}$ inches × $3\frac{1}{2}$ inches. It was dark grey in colour, fairly clean, hard, and very tenacious.

The balata had the following composition:—

	Per cent.
Moisture	1·8
Gutta	45·7
Resin	44·2
Proteid	3·0
Insoluble matter	5·3
Ash	1·28

This sample of balata is of good quality, agreeing well in composition with the average figures for commercial consignments. It was valued at 1*s.* $7\frac{1}{2}$*d.* per lb. in London.

Latex of *Mimusops* sp. from Southern Nigeria (1907).

This sample of latex was stated to have been derived from a species of *Mimusops*, probably *Mimusops Djave*.

The latex was very thick, of grey colour, and had an unpleasant odour. It contained a large quantity of vegetable impurity.

The latex was found to be readily coagulated in the cold by the addition of glacial acetic acid, dilute alcohol or acetone.

400 grams of the impure latex were diluted with an equal volume of water and strained through muslin; the residual impurities weighed about 150 grams. The weight of the solid coagulum obtained, after drying in the air, was about 200 grams.

The solid material had the following composition:—

	Per cent.
Moisture	14·7
Gutta?	27·6
Resin	56·1
Proteid	1·0
Insoluble matter	0·6
Ash	0·45

The material therefore consists largely of resin, over 65 per cent. of this constituent being present in the dry product.

The substance returned as "gutta" did not possess the characters of the gutta of true gutta percha. It was a very friable material which became coherent and plastic on immersion in warm water but had no tenacity; it returned to a friable condition on cooling.

The material could not be utilised as a substitute for gutta percha and would have very little commercial value.

LATEX OF *Mimusops multinervis* FROM SOUTHERN NIGERIA (1910).

The latex, which had not coagulated during transit, measured about one pint. On removing the cork a small quantity of gas, possessing a disagreeable odour, was given off.

On coagulation the latex furnished a sticky product which hardened and became brittle on standing. The yield of the dry material amounted to 29 per cent. of the weight of the latex.

An analysis of the dry material gave the following results:—

	Per cent.
Gutta?	29·3
Resin	66·1
Protein	3·3
Ash	1·3

The constituent returned as gutta in the analysis was a somewhat friable material, which softened and became plastic on warming.

It is clear from the analysis that the product obtained from the latex of *Mimusops multinervis* is of resinous nature, and on account of its brittle character it is not likely to be of commercial value.

APPENDIX.

THE UTILISATION OF THE SEEDS OF THE PARA RUBBER TREE.

In view of the interest which is now being taken in the possibility of utilising the kernels of Para rubber seed as a source of oil and feeding cake for cattle, it seems desirable to summarise for general information the reports which have been made by the Imperial Institute on the subject. The commercial value of the oil as a substitute for linseed oil has been fully established, and consignments of the oil or of the dried kernels would be readily saleable at prices depending on the current value of linseed oil. Feeding trials have been made on a small scale with Para rubber seed cake, and have given satisfactory results, but further trials extending over a longer period are required before the value of the material as a cattle food can be definitely stated.

I.—*Para Rubber Seed and Para Rubber Seed Meal* (1903).

Specimens of Para rubber seed and of meal prepared from them were forwarded to the Imperial Institute in 1902 from the Straits Settlements and the Federated Malay States, and the results of their examination are given in the following report:—

Para Rubber Seed.

The kernels constitute about 50 per cent. by weight of the whole seeds. On extraction with light petroleum they yielded 42·3 per cent. of oil (specimen A), whilst the whole seed (husk and kernel ground together) furnished 20 per cent. of oil (specimen B).

The oil obtained from the kernels alone is clear, of light yellow colour, and has an odour somewhat resembling that of linseed oil. It belongs to the class of drying oils, and yields a clear, transparent film when allowed to dry by exposure to air. The husks contain a solid fat which has a high saponification number and a low iodine value, but since the amount of this solid fat in the husks is very small it makes but little difference to the properties of the oil obtained from kernels and husks ground together. The following table gives the constants found for both specimens of the oil, those of linseed oil being added for comparison:—

—	Para Rubber Seed Oil. A. (from kernels only).	Para Rubber Seed Oil. B. (from whole seed).	Linseed Oil.
Specific gravity at 15° C.	0·9302	0·9316	0·931—0·937
Free fatty acids—			
Acid value	10·7	19·0	—
Calculated as oleic acid	5·4 %	9·6 %	—
Ester value	195·4	190·3	—
Neutral oil	94·6 %	90·4 %	95·5—99·6 %
Saponification value	191·8	193·0	190—195
Iodine value	128·3	121·2	170—194

On saponification with caustic soda, Para rubber seed oil yields a rather soft soap of yellowish colour. It was found that the time required for the complete saponification of this oil is about half as much again as that required in the case of olive oil.

Para Rubber Seed Meal.

The sample consisted of about 7 lb. of finely ground meal of pale buff colour; it was free from husk, and possessed the pleasant odour characteristic of oil meals.

Extraction and Examination of the Oil contained in the Meal.

On extraction with light petroleum, the meal yielded 36·1 per cent. of an oil which had a slightly rancid odour, and, on standing, solidified as a soft, crystalline, yellow mass. It furnished the following constants:—

Specific gravity at 15° C.	... ...	0·911	
Free fatty acids	Acid value	130·5	
	Free acids (calculated as oleic acid)	65·6	per cent.
Neutral oil	... ...	34·4	,,
Ester value	... ...	65·2	
Saponification value	... ...	195·7	
Iodine value	... ...	136·2	

When heated, the oil began to melt at 19° C., and was a clear liquid at 28° C. It had very marked drying properties, and yielded a solid, transparent film. On saponification with caustic soda, the oil furnished a rather soft soap of a yellowish colour.

In the following table, the constants and properties of the oil extracted from this sample of meal are contrasted with those of the oil obtained from the freshly crushed decorticated seeds; the constants of linseed oil are again added for comparison.

—	Oil extracted from Para Rubber Seed Meal.	Oil extracted from decorticated Para Rubber Seeds (freshly crushed).	Linseed Oil.
Yield of oil, per cent.	36·1	42·3	33–38
Physical state	Solid below 19° C.	Liquid at 15°C.	Liquid at 15°C.
Specific gravity 15°/15°C. ...	0·911	0·9302	0·931–0·937
Free fatty acids, per cent. (calculated as oleic acid).	65·6	5·4	—
Iodine value	136·2	128·3	170–194

It will be observed that the oil extracted from the meal was solid, whereas that obtained from the freshly ground seed was liquid. The difference is due to the large proportion (65·6 per cent.) of free fatty acids present in the former, whilst the latter contained only 5·4 per cent. of free acids. The cause of this difference in the two oils has been investigated, and it has been found that after the seed has been crushed the oil gradually undergoes decomposition, owing to the action of a hydrolytic enzyme contained in the seed.

Analysis of the Meal.

The meal furnished the following results on analysis:—

	Per cent.
Moisture	9·1
Ash	3·53
Fibre	3·4
Oil	36·1
Proteids	18·2
Carbohydrates	29·67

The ash was found to contain 30·3 per cent. of phosphoric acid (calculated as P_2O_5) present in the form of phosphates, which is equivalent to 1·07 per cent. of phosphoric acid in the meal.

The results of this examination of the Para rubber seed meal indicate that the material thus prepared could neither be used as a feeding stuff, owing to the presence in it of large quantities of free fatty acids, nor for the expression of Para rubber seed oil since the latter has been largely decomposed. It is probable, however, that if the oil were expressed from the decorticated seeds, the residual cake could be utilised as a feeding material, as is shown by the following comparison between the calculated composition of such a cake and the compositions of some commercial feeding cakes:—

—	Moisture.	Ash.	Proteids.	Fibre.	Fat.	Carbo-hydrates.	Nutrient value.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Para rubber seed cake ...	13·36	5·19	26·81	5·00	6·00	43·64	84·25
Linseed cake	11·16	5·20	29·50	9·10	9·50	35·54	133
Cottonseed cake (decorticated).	9·0	7·10	43·78	5·18	11·38	23·56	161

These figures show that a cake prepared from Para rubber seed kernels would compare favourably with other cakes as a cattle food, and would contain a particularly low proportion of indigestible matter (fibre).

Commercial Value.

Specimens of both the seeds and oil have been submitted to leading brokers. They report that the oil could probably be used as a substitute for linseed oil and would be worth about 20*l.* per ton, but that oil merchants would not take it up unless they first had an opportunity of testing it in bulk. The brokers consider that it would be more profitable to ship the seeds themselves to this country, as is done in the case of most other oil seeds. They value the decorticated seeds at 10*l.* to 12*l.* per ton, and add that they would be prepared to take two or three tons at the lower price in order to introduce them into the market.

The Para rubber seed meal was not commercially valued, since in its present condition it could not be utilised in any way. Para rubber seed "cake" of the composition already given should be almost as valuable as linseed cake, which sells at from 5*l.* 15*s.* to 6*l.* 15*s.* per ton.

The results of this investigation lead to the conclusion that the seed of the Para rubber tree is a valuable economic product, and is likely to become of considerable commercial importance.

The oil possesses properties very similar to those of linseed oil, and should therefore be suitable for the preparation of paints and varnishes, and for the manufacture of rubber substitutes, linoleum and waterproofing materials. It could probably also be used like linseed oil for the manufacture of soft soap. The cake left after expressing the oil from the decorticated seeds would probably be of value as a cattle food, since its calculated composition compares very favourably with the various cakes at present in use, and it is stated that animals readily eat the kernels in the Straits Settlements.

The results obtained in this investigation of Para rubber seed have since been confirmed by the examination of a number of further samples of the seed which have been forwarded to the Imperial Institute.

II.—*Para Rubber Seed Oil from the Federated Malay States* (1908).

A small consignment of Para rubber seed oil which had been prepared by expression at the Perak Museum was received at the Imperial Institute for examination. It was stated that the press used was not very efficient, and that the best result obtained was a yield of 34 per cent. of oil from the dried kernels.

The oil was light brown, slightly cloudy, and deposited a brown muddy sediment. After filtration a bright yellow oil was obtained which gave the following results on examination:—

	Present sample.	Previous sample.
Specific gravity at 15·5/15·5° C. ...	0·925	0·9302
Acid value	16·8	10·7
Saponification value	192·1	191·8
Iodine value	131·4	128·3

It will be seen that the constants of the expressed oil agree closely with those obtained for the previous sample of oil which was extracted at the Imperial Institute from the kernels by petroleum ether.

Samples of the oil were submitted to manufacturers, who confirmed the opinion, previously expressed, that Para rubber seed oil could be utilised as a substitute for linseed oil. The results of technical trials showed that it could be employed in the manufacture of paints or of soft soap. It is, however, inferior in drying power to linseed oil (as would be expected from its lower iodine value), and would consequently command a lower price.

III.—*Para Rubber Seed Cake* (1911).

A small quantity of Para rubber seed cake, obtained on expressing the oil from the kernels, was forwarded to the Imperial Institute for examination in order to determine its suitability for use as a feeding stuff for cattle.

The cake was fairly soft, and arrived in a very broken condition, much powder being present.

An analysis furnished the following results:—

	Per cent.
Moisture	6·91
Crude proteins	29·93
Consisting of—	
True proteins	27·03
Other nitrogeneous substances	2·90
Fat	17·68
Starch, &c. (by difference)	35·97
Fibre	4·82
Ash	4·69

Nutrient ratio:—1 : 2·56

(The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent).

Food units:—155

(The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins).

The cake does not contain saponin nor any alkaloid; if any cyanogenetic glucoside be present the amount is less than that necessary to yield 0·01 per cent of hydrocyanic acid.

It will be seen from the following table that this Para rubber seed cake compares very favourably in composition with the feeding cakes in common use:

—	Para Rubber Seed Cake.	Soya Bean Cake.		Linseed Cake.		Cotton Seed Cake.	
		English.	Imported.	Average English.	American.	Average Decorticated.	Undecorticated English.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ..	6·91	12·70	17·00	11·16	9·30	9·00	3·75
Crude Proteins	29·93	38·82	40·60	29·50	33·37	43·78	24·62
Fat	17·68	11·07	9·00	9·50	10·06	11·38	6·56
Carbohydrates (by difference)	35·97	26·51	23·78	35·54	31·84	23·56	29·28
Fibre	4·82	5·85	1·47	9·10	10·37	5·18	21·19
Ash	4·69	5·05	5·25	5·20	5·06	7·10	4·60
Food Units ...	155	151	147	133	140	161	107

The present sample of Para rubber seed cake contains more fat than is desirable, and it would be advantageous to submit the kernels to greater pressure in order to extract more of the oil and thus produce a harder cake.

Feeding Trials.

Feeding trials have been conducted for the Imperial Institute with this cake on cows and sheep, and the following report has been furnished:—

A quantity of the cake was moistened with water and fed to the cows. All, except three which are usually averse to new foods, ate it readily. The dry and powdery condition of the cake suggested the moistening of it before feeding, and it was found that it absorbed its own weight of water, and was then more appetising than when fed dry. Several cows refused it in the dry state, and ate it readily when moist.

Three cows received the cake daily for five days, getting 4 lb. each day. They all ate it readily, and no scouring or binding effects were noticeable, nor did the milk or cream appear affected in any way.

The cake was fed in the dry state to the sheep and was eaten fairly readily. Some sheep ate their full allowance when it was mixed with other foods, but apparently had less liking for it when fed alone. No exceptional effects were noticed.

A more extended trial with a larger number of animals and a larger daily allowance of the cake would be necessary before the safe limits and effects of this food could be stated.

The results of these trials are satisfactory so far as they go, but, as stated above, it will be necessary to conduct trials extending over a much longer period before a really useful opinion as to the feeding value of Para rubber seed cake can be formed.

IV.—*The Utilisation of Para Rubber Seed.*

Since the kernels of Para rubber seed were first investigated at the Imperial Institute in 1902-3, small consignments have been received from time to time in London and sold as oil seeds, but there has been no large development of this trade, mainly because the demand for seed for planting has been so large as to preclude the collection of seed for industrial use, and, further, the profits from sales of rubber on developed estates have been so large in recent years that little or no attention has been given to the utilisation of by-products. Now, however, when the area of productive Para rubber plantations is increasing rapidly every year, it seems likely that this indifference to the possibility of using these kernels will disappear, and already the expression of oil from the kernels has been undertaken at one or more mills in the East Indies.

It is opportune, therefore, to call attention to several practical difficulties which may occur in dealing with these kernels, and to methods of overcoming them.

Considerable difference of opinion exists as to the cost of collecting Para rubber seeds. The late Mr. Carruthers, in his report as Director of Agriculture for the Federated Malay States in 1908, estimated that 1,000 seeds could be collected there for 4 cents (1·1*d.*), and that 414,400 seeds would be needed to produce 1 ton of kernels. From these data he calculated that the cost of collecting and shelling 1 ton of kernels would be $21·14 ($1 = 2*s.* 4*d.*).

This estimate is considered far too low by Messrs. Macmillan and Petch (*Journ. d'Agric. Trop.*, 1910, 10. 284, and *Circulars and Agr. Journ, Roy. Bot. Gard. Ceylon*, 1908, 4, 90), who point out that in Ceylon the cost of collecting 1,000 seeds is 4*d.*, and that Mr. Carruthers' estimate of the number of seeds required to produce 1 ton of kernels is based on the weight of seeds from untapped trees. It has been shown in Ceylon that seeds from tapped trees are smaller and lighter than those from untapped trees, and Messrs. Macmillan and Petch estimate that from tapped trees at least 700,000 seeds would be needed to produce 1 ton of kernels. Accepting their data, the cost of collecting sufficient seed to produce 1 ton of kernels would be £11 13*s.* 4*d.*, which is certainly a prohibitive price so far as the export of these kernels as an oil seed is concerned. It should be pointed out that Messrs. Macmillan and Petch's criticism of Mr. Carruthers' estimate is mainly directed to the question of the quantity of seeds required to produce 1 ton of kernels, whereas the principal difference between the two estimates lies in the cost of collection, which appears to be nearly four times as great in Ceylon as in the Federated Malay States. In this connection it may be mentioned that Mr. Ridley, Director of the Singapore Botanical Gardens, has suggested that the right of seed collection in plantations in the Straits Settlements might be leased to Chinese, who would be able to utilise for this purpose the labour of village children. If this plan is feasible it would appear to afford a comparatively simple solution of the labour difficulty in Malaya.

For shelling the seeds, the installation of machinery is desirable. Trials with Miller's nut-cracking machine at the Imperial Institute have shown that this can be used for the purpose; but it is necessary that trials on a comparatively large scale with the various machines available should be made before definite recommendations in favour of any one make are made. It is essential that the machine adopted should crack the shells without damaging the kernels, since the latter deteriorate somewhat rapidly when

they are broken and exposed to air. This is of small importance when the kernels are to be utilised locally and at once for the expression of oil, but it becomes all-important if the kernels are to be exported.

Kernels for export should be thoroughly dried in the sun before being packed in bags for shipment. When these precautions are taken it is quite clear that the kernels can be shipped to Europe, and will arrive in sound condition. In 1909 a small experimental shipment was made to this country from Ceylon, and it behaved quite satisfactorily on expression and furnished oil of excellent quality. This year a further small shipment of kernels was received at Liverpool, and a sample of these, kindly supplied to the Imperial Institute by the purchasers, was found to be in good condition, and to give a normal yield of oil of good quality.

In expressing Para rubber seed oil trouble may arise from the presence of a fat-splitting enzyme in the kernels, as this is taken out with the water expressed along with the oil, and if this aqueous layer is left in contact with the oil, the latter will be rapidly hydrolysed into glycerine and fatty acids. A similar fat-splitting enzyme, however, occurs in castor seed, and this occasions no difficuty in the industrial preparation of castor oil, and it may be assumed that with due care no trouble will arise with Para rubber seed kernels from this cause.

In determining the value of an oil seed the amount of oil present is the factor of prime importance, but much also depends on the nature of the cake left after expression of the oil. If this contains no deleterious ingredients and is rich in nutritive materials and poor in indigestible fibre, it can be used as a feeding-stuff for cattle, but if deleterious ingredients are present the material can, as a rule, only be employed as a manure. Unfortunately Para rubber seed kernels contain a cyanogenetic glucoside and an enzyme which decomposes this in the presence of water, yielding prussic acid as one product. This, however, is also true of linseed cake, perhaps the most popular feeding stuff with farmers in this country at the present time, so that the mere production of small quantities of prussic acid affords no ground for suggesting that cake from Para rubber seed kernels will be unsuitable for feeding cattle. It is, however, of the greatest importance to determine as soon as possible what the average maximum yield of prussic acid from cake made from these kernels under industrial conditions is, and if this proves to be no larger than that obtained from linseed cake on the average, it may be assumed that the cake is worth trial as a feeding-stuff. With all new feeding-stuffs it is desirable that extensive preliminary feeding trials should be made before the material is placed on the market, and even should Para rubber seed cake prove to yield less prussic acid than average linseed cake, it will still be indispensable that feeding trials should be made with it. The preliminary trials referred to on page 438 have given promising results but require to be supplemented by experiments on a larger scale.

Recently a detailed examination of Para rubber seed oil has been made in the Scientific and Technical Department of the Imperial Institute, and the results are given in a paper by S. S. Pickles, D.Sc., and W. P. Hayworth, F.I.C., which has been communicated to the Society of Public Analysts (*Analyst*, 1911, *36*, 491). The results show that the oil consists of a mixture of glycerides of linolenic, linoleic, oleic, and stearic acids, with possibly some palmitic acid.

The proportion of unsaturated acids present is lower than in linseed oil, as was to be expected from the slower "drying" character shown by Para rubber seed oil.

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No. 88.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT.

Edited by the DIRECTOR.

V.—OIL-SEEDS, OILS, FATS, AND WAXES.

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No. 88.

IMPERIAL INSTITUTE.

SELECTED REPORTS FROM THE SCIENTIFIC AND TECHNICAL DEPARTMENT. EDITED BY THE DIRECTOR.

V.—OIL-SEEDS, OILS, FATS, AND WAXES.

INTRODUCTION.

The materials dealt with in the present part of this series of Selected Reports include oil-seeds and fixed oils, fats, and waxes of vegetable or animal origin; essential oils (volatile oils) will be dealt with in a separate part.

OIL-SEEDS.—Most of the vegetable oils and fats of commerce are obtained by expression or extraction from the seeds of plants, though in a few cases, *e.g.*, olive oil, the oil is derived from the fruit pulp. The value of an oil-seed depends partly on the amount and nature of the fat or oil it contains, and partly on the composition of the residue left after the oil or fat has been expressed from the seed.

FIXED OILS AND FATS.—These consist chiefly of mixtures of glycerides of fatty acids, with, as impurities, small quantities of colouring matter and unsaponifiable matter. They are conveniently divided into the following four classes:—

1. Drying oils.
2. Semi-drying oils.
3. Non-drying oils.
4. Fats.

1. *Drying Oils.*—These oils when exposed to light and air in thin layers "dry," forming tough films, which are generally transparent: such oils are consequently employed in the manufacture of paints and varnishes but are unsuitable for use as lubricants. Their "drying" properties are due to the presence of glycerides of unsaturated acids such as linolenic and linoleic acids, which undergo oxidation and other changes on exposure to air. They have iodine values (see p. 444) ranging from about 125 to 206 per cent. Generally speaking, the higher the iodine value of an oil the greater its drying power. Linseed oil is the most important member of this class.

2. *Semi-drying Oils.*—These oils "dry" only after prolonged exposure to light and air, and do not as a rule yield sufficiently hard and tenacious films to allow of their use in paint or varnish manufacture; they are generally unsuitable for lubrication and are chiefly utilised in the manufacture of soaps and candles, though some of them also find application for illuminating purposes and the best of them are also used as edible oils. The iodine values of oils of this class vary from about 94 to 125 per cent. Cotton seed and rape seed oils are important and typical members of this class.

3. *Non-drying Oils.*—These oils remain quite liquid on exposure to air and are consequently largely employed as lubricants; they are also used as edible oils and the poorer qualities are utilised in soap manufacture. All the important oils included in this group have iodine values of less than 100 per cent. The best-known member is olive oil, which has an iodine value of 79 to 88 per cent.

4. *Fats.*—Such oils as are solid or semi-solid at ordinary European temperatures are often termed fats. It should be pointed out, however, that this distinction is difficult to maintain since a product such as palm oil is a semi-solid fat when imported to this country, but is liquid at the high temperatures prevailing in West Africa. Fats, with a few exceptions, have iodine values of less than 75 per cent.

The solid or semi-solid nature of fats is due to the predominance in them of glycerides of high melting point, such as palmitin or stearin.

WAXES.—The waxes differ from the oils and fats in that the fatty acids are not combined with glycerol but with other alcohols, such as cetyl, ceryl or myricyl alcohol, no glycerides being present; thus beeswax consists principally of cerotic acid and myricin, a compound of myricyl alcohol and palmitic acid. These alcohols are insoluble in water, whilst glycerol is soluble, and consequently the waxes yield large quantities of "unsaponifiable matter." The waxes are generally solid bodies of harder consistence and higher melting point than the fats.

METHODS OF INVESTIGATION.

The following is a brief description of the methods of investigation employed for these products, with indications of the manner in which the results obtained may be interpreted:—

Examination of Oil-seeds.

In the case of samples of such oil-seeds as are already of commercial importance, the sample under examination is compared with standard commercial samples, differences in colour, average weight of seed, or freedom from dirt and foreign seeds being noted. In the case of new oil-seeds, examination of the structure of the seeds is made, as although seeds may contain oil in sufficient quantity to render them of commercial importance, the nature of the seed coat, such as a hard, thick or heavy shell, may prevent their commercial utilisation.

Estimation of Moisture.—A weighed portion of finely divided seed is dried at 100° C. In the case of oil-seeds containing drying oils the material is dried in a current of carbon dioxide, or other inert gas, to prevent errors arising from absorption of oxygen from the atmosphere by the oil. The quantity of moisture varies with the state of maturity of the seed and the conditions under which it has been prepared and stored. Its determination is of importance in order that the actual oil or fat content of the dry seed may be calculated, and comparable results for different samples obtained, free from the influence of such a variable factor as the moisture content.

Estimation of Oil or Fat.—A quantity of finely ground seed is placed in a Soxhlet extractor and extracted with light petroleum until free from oil; the solvent is then removed from the oil by evaporation, the last traces being got rid of by heating the oil to 100° C. *in vacuo* until it ceases to lose weight. Large laboratory samples of oil for examination are prepared by similar methods.

Examination of Oils

Preliminary.—Any peculiarities in appearance, such as colour or turbidity, and in taste are noted. The drying power is then tested by spreading a thin film of the oil on a glass plate and exposing to air in a warm place.

Previous to chemical examination any water or suspended matter in the oil is removed by heating and filtering the oil; in some cases moisture and dirt (suspended insoluble matter) are present in appreciable quantities and are then quantitatively estimated.

Specific Gravity.—In the case of liquid oils this constant is generally determined by comparison with water at 15·5° C.; with solid fats a higher temperature is employed, generally 99-100° C.

Acid Value.—The acid value is determined by titrating a weighed quantity of the oil or fat, mixed with pure neutral alcohol, with standard caustic potash (potassium hydroxide) solution, using phenolphthalein as indicator. The acid value is the number of milligrams of potassium hydroxide required to neutralise the free acids in 1 gram of the oil or fat.

Saponification Value.—To a weighed quantity of the oil is added a quantity of a standard alcoholic solution of caustic potash in excess of that required to completely convert the oil into soap. The liquid is then boiled until globules of oil are no longer visible, showing that saponification is complete, after which the excess of caustic potash is determined by titration with standard hydrochloric acid using phenolphthalein as indicator. The number of milligrams of caustic potash required to convert 1 gram of oil into soap is termed the "saponification value" and is constant, within certain limits, for each kind of oil.

Iodine Value by Hübl's Method.—A weighed quantity of the oil is dissolved in pure chloroform and allowed to stand over night (about 17 hours) with an excess of a standard alcoholic solution of iodine and mercuric chloride. The operation is carried out in a tightly stoppered bottle placed in a dark cupboard. At the end of 17 hours the excess of free iodine is estimated by titration with standard sodium thiosulphate solution in the usual manner.

The iodine value is expressed as the percentage by weight of iodine absorbed by the oil. This is a measure of the amount of unsaturated glycerides (*e.g.*, glycerides of linolenic and linoleic acids) contained in the oil, and, as already indicated, serves to distinguish "drying" from "semi-drying" or "non-drying" oils.

Hehner Value.—This indicates the percentage amount of insoluble fatty acids together with any unsaponifiable matter in the oil, and is determined by saponifying a weighed quantity of the oil with caustic potash. The fatty acids are liberated from the soap so formed by adding an excess of dilute sulphuric acid, then melted by heating, and washed with dilute sulphuric acid and finally with hot water on a thick filter paper until free from mineral acid. They are then dried at 100° C. and weighed.

Unsaponifiable Matter.—A weighed portion of the sample is saponified with caustic potash, and then extracted with ether, which removes the unsaponifiable matter together with some soap. The ethereal solution is then washed with water and dilute caustic potash, to remove any soap, dried with anhydrous sodium sulphate, evaporated to dryness, and the unsaponifiable matter left as a residue weighed. The result is expressed as a percentage of the oil or fat. Owing to difficulty in separating the unsaponifiable matter from the soaps, this estimation cannot be carried out with great accuracy. The unsaponifiable matter contains such substances as phytosterol in vegetable oils and cholesterol in animal fats, together with other bodies.

Titer Test.—This is the temperature at which the insoluble fatty acids solidify. The fatty acids, prepared as already described (see above), are dried and filtered into a test tube until this is about half filled with the melted fatty acids. The test tube is then fitted into a wide-mouthed bottle, to prevent rapid or uneven cooling by draughts of air, a delicate thermometer is inserted in the liquefied acids, and when a few crystals appear at the bottom of the tube, the acids are carefully stirred and the temperature, in Centigrade degrees, noted from time to time. This at first falls, but later rises suddenly some tenths of a degree to a point at which it remains stationary for a short time before it again falls; this is the "titer" or solidifying point.

Reichert-Meissl Value.—This is a measure of the amount of volatile fatty acids contained in an oil, and is determined in the following manner:—Five grams of fat are carefully saponified with excess of caustic potash dissolved either in alcohol or glycerol; the fatty acids are liberated by means of dilute sulphuric acid and the liquid distilled in such a way that 110 c.c.

distil over in about one hour. One hundred c.c. of this solution are filtered off and titrated with decinormal caustic potash solution, using phenolphthalein as indicator. The number of cubic centimetres of the standard alkali used multiplied by 1·1 is the "Reichert-Meissl" value. As it is impossible to completely separate the volatile from the non-volatile fatty acids this test must always be carried out under identical conditions. It is largely employed in the examination of butter for the presence of substitutes prepared from vegetable oils and fats.

As a general rule, the examination of the oils dealt with in this publication has been made with one of two objects in view, viz., (1) to ascertain the essential identity of the material with a known commercial product, or (2) to determine the nature of the oil and the class to which it belongs with a view to ascertaining to what industrial uses it can be applied, and consequently what its commercial value may be.

The results obtained in the various operations described above afford useful information as regards both these matters. The figures obtained in these determinations are usually fairly constant for a particular kind of oil, and therefore serve to identify a sample if the typical constants of that oil have been recorded previously.

In the case of an unknown oil the figures obtained in such determinations serve to indicate the class to which the oil belongs and the purposes to which it may be applied. Thus an oil with a high iodine value will probably dry well and be suitable for the manufacture of paints and varnishes. Oils containing more than traces of unsaponifiable matter are unsuitable for use as edible oils, as are also oils possessing an unpleasant flavour or dark colour, which cannot be removed by ordinary commercial refining processes. An oil with a high acid value would be unsuitable for use as a lubricant, as the free acids would be likely to cause corrosion of metallic surfaces. The "titer" test is a useful indication to the soapmaker of the consistence of the soap which an oil will yield.

The present part of Selected Reports from the Scientific and Technical Department of the Imperial Institute includes all the more important reports on oil-seeds, oils, fats and waxes made to Colonial, Indian and other Governments between January 1st, 1903, and December 31st, 1912. Most of the experimental work recorded has been conducted by various members of the staff of the Scientific and Technical Department, especially Mr. R. G. Pelly, F.I.C. The Imperial Institute is also indebted to a number of external experts and firms for conducting technical trials and giving valuations of these products. Among these may be mentioned especially Messrs. The British Oil and Cake Mills, Ltd.; Messrs. Joseph Crosfield and Sons, Ltd.; Messrs. Lever Bros., Ltd.; Messrs. J. Bibby and Sons, Ltd.; Messrs. The Hull Oil Manufacturing Co., Ltd.; Messrs. Lewis and Peat; Messrs. The Produce Brokers Co., Ltd.; and as well as the late Dr. Julius Lewkowitsch.

DRYING OILS.

The most important drying oil of commerce is linseed oil, derived from the seeds of the flax plant (*Linum usitatissimum*).

Tung oil (Chinese wood oil) derived from the seeds of species of *Aleurites* is also an important oil in this class, as can be seen from the following table showing the exports of this oil from Hankow in recent years:—

Tung Oil.

1907.	1908.	1909.	1910.	1911.
Tons.	Tons.	Tons.	Tons.	Tons.
23,539	35,093	27,506	45,057	35,083
£	£	£	£	£
539,811	648,576	471,728	868,321	785,318

The following materials belonging to this class have been examined and reported on:—

Linseed (*Linum usitatissimum*).
Niger seed (*Guizotia oleifera*).
Hemp seed (*Cannabis sativa*).
Aleurites Fordii seed and oil.
Aleurites triloba seed and oil.
Para rubber (*Hevea brasiliensis*) seed and oil.
Ceara rubber (*Manihot Glaziovii*) seed and oil.
"Nsa-sana" (*Ricinodendron africanus*) seed and oil.

LINSEED.

The importance of this oil-seed may be judged from the fact that in 1910, 1,489,435 quarters (of 416 lb.), valued at £4,529,974, and in 1911, 1,393,874 quarters, valued at £4,728,536, were imported to the United Kingdom alone. At the present time linseed is quoted at about 42*s.* per quarter, and linseed oil at £22 per ton (Nov. 1913).

SUDAN.

This was a fine sample of linseed, which would command very good prices. Commercial experts stated that it would be worth 47*s.* 6*d.* per quarter, but that it would only realise this price in small quantities. It would, however, sell freely at about 44*s.* per quarter (current price, May, 1906).

EAST AFRICA PROTECTORATE.

This sample of linseed was described as "sown on the 21st April and reaped on the 22nd August." It was forwarded by the Director of Agriculture.

Commercial experts stated that it was of good quality and worth from 40*s.* to 42*s.* 6*d.* per quarter (December, 1905).

A further sample, grown near Gilgil, was received in April, 1912. This was also of very good quality, and was valued at 69*s.* per quarter for crushing (June, 1912).

NATAL.

This linseed was received in December, 1908. The sample consisted of rather large flat seed, showing a few perished grains but practically free from impurities.

The seed was submitted to commercial experts, who stated that it was of good quality, but out of condition, possibly owing to damp. They valued it (March, 1909) at £11 per ton, and added that to obtain this price it should be delivered in good condition in small lots of 50 to 100 tons. If delivered in quantities of 500 or 1,000 tons it would probably not realise more than £10 10*s.* per ton.

MAURITIUS.

This sample consisted of linseed in good condition, a very few foreign seeds and a small amount of shrivelled seed were present. The seeds yielded 38·4 per cent. of oil, compared with 32 to 42 per cent. recorded for commercial linseed. The oil had the usual appearance of linseed oil.

Linseed, represented by this sample, would realise the current price of the product if marketed in good condition, viz., 64*s.* to 72*s.* per quarter of 416 lb. (October, 1911).

For a detailed account of the cultivation and preparation of linseed and the uses of the seed and oil, see "*Bulletin of the Imperial Institute*" (1911, **9**, 355).

NIGER SEED.

EAST AFRICA PROTECTORATE.

This sample of Niger seed, *Guizotia* sp., was grown at the Kabete Experimental Farm. It contained 37·6 per cent. of oil, as compared with 40 to 45 per cent. in commercial Niger seed. The seed was submitted to oil manufacturers in the United Kingdom, who stated that both Niger seed oil and cake were well-known products, but that very little of this seed was imported into the United Kingdom. If shipped regularly from East Africa it should have no difficulty in finding a market here.

The oil could be used as a substitute for linseed oil in making soft soap, and on that basis the seed was valued at 36*s.* to 38*s.* per quarter of 416 lb., ex ship Hull (September, 1909), but it was pointed out that it might fetch a higher price in Marseilles, where the seed is said to be employed for the manufacture of edible oil.

HEMP SEED.

HONG KONG.

This was a sample of small, greyish seeds with the usual appearance of hemp seed. A number of the seeds had been attacked by insects, and the sample contained over 2 per cent. of foreign grains, dust, &c.

The hemp seed, freed from the foreign grains, &c., yielded 28·2 per cent. of liquid yellowish-green oil, as against 30 per cent. obtained from hemp seed of average commercial quality.

The seed was submitted to a large firm of oil-seed crushers, who reported that it was dull, dirty, and small, and generally rather poor in quality, whilst the yield of oil was low, and the percentage of woody fibre high. They valued the sample at not more than £8 5s. per ton in Europe (February, 1912), against £9 to £9 10s. for ordinary good hemp seed. A firm of brokers stated that the seed was of inferior quality to that imported from Manchuria, and yielded less oil, and valued it at not over £9 per ton for crushing purposes (February, 1912), adding that a limited quantity might be sold as bird seed at £10 per ton.

TUNG OR CHINESE WOOD OIL.*

(*Aleurites Fordii*).

HONG KONG.

The seeds of a species of Aleurites, since identified at Kew as *Aleurites Fordii*, Hemsl., were forwarded for examination to the Imperial Institute from Hong Kong in April, 1906.

It was stated that this species of Aleurites is one of the trees grown in China for the production of Chinese wood-oil (tung oil), and that it occurs in Fokien Province intermixed with *Aleurites cordata*, which was formerly considered to be the sole source of wood-oil. It was thought, therefore, that it would be of interest to have an examination made of the oil from the seeds of the new species, in order to determine its quality in comparison with that of the tung oil of commerce, which appears to be prepared indiscriminately from the seeds of *Aleurites cordata* or *Aleurites Fordii*, or mixtures of the two.

The sample consisted of two bags of nuts weighing 500 grams. The kernels of the nuts were fresh and in good condition on arrival.

On extraction with light petroleum, the kernels were found to contain 58·3 per cent. of oil, equivalent to a yield of 36·4 per cent. from the entire nuts. The oil was light in colour, and, on exposure to air in a thin layer, dried in a day at the ordinary temperature, giving a varnish-like residue. On heating in a water-oven at 100° C. the oil dried and formed a resin-like solid.

The "constants" of the oil were determined and found to agree well with those recorded for commercial samples of tung oil, as shown in the following table:—

	Oil from seeds of *A. Fordii*.	Commercial Tung oil.
Specific gravity at 15° C.	0·9404	0·933–0·942
Acid value	2·89	—
Saponification value ...	191·8	190–197
Iodine value	166·7	149–165
Hehner value	94·6	96·3
Titer test	42°–42·5° C.	37·1°–37·2° C.

* Since these reports were prepared for publication Mr. E. H. Wilson has shown that the two Chinese species concerned are *Aleurites Fordii* Hemsl. and *A. montana* Wilson, and that the former yields practically all the Chinese wood-oil of commerce (*Bull. Imp. Inst.* 1913, 11., 441).

The oil extracted from the seeds of *Aleurites Fordii* is similar in composition to the tung oil of commerce. It is, however, lighter in colour, and produces a lighter-coloured varnish on drying, so that it is probably a purer product. It is noteworthy also that it has a higher titer test than commercial tung oil.

CANDLE NUTS (*Aleurites triloba*).

HONG KONG.

A sample of the seeds of *Aleurites triloba*, Forst., was forwarded for examination to the Imperial Institute by the Superintendent of the Botanical and Forestry Department, who stated that it is one of the best shade trees in Hong Kong, and that it grows very quickly.

The seeds of this tree, which is frequently referred to in technical literature as *Aleurites moluccana*, given as a synonym for *A. triloba* in the Index Kewensis, are commercially known as "candle nuts," and the kernels are already exported from Fiji and elsewhere. The oil they contain is used for soap-making and other purposes, both in this country and on the Continent.

The sample consisted of four pounds of the seeds, the kernels of which were nearly white, and free from discoloration.

The oil was extracted by means of light petroleum, and the kernels were found to contain 60·8 per cent. of oil, which is equivalent to a yield of 19·8 per cent. from the unshelled seeds. The oil dried on exposure to air in thin films in about ten days.

A number of analyses of candle-nut oil have been made previously, and these show considerable variation in the principal constants recorded. The results obtained at the Imperial Institute by the analysis of oil extracted from the present sample of seeds, and those obtained by investigators who have examined candle-nut oil previously, are given in the following table:—

—	Oil from *Aleurites triloba*, examined at the Imperial Institute.	Oil from *Aleurites moluccana*, examined by		
		Lewkowitsch.	De Negri.	Fendler.
Specific gravity at 15°C.	0·9274	0·92565 (15·5°C.)	0·920	0·9254
Acid value	1·72	—	—	—
Saponification value ...	204·2	192·62	184–187·4	194·8
Iodine value	139·7	163·7	136–139	114·2
Hehner value	96·4	95·5	—	—
Reichert-Meissl value...	1·98	—	—	1·2
Titer test	17·8° C.	—	20°–21° C.	18° C.

These results indicate that the oil belongs to the class of drying oils typified by linseed oil, and would be suitable for the manufacture of soft soap, the preparation of oil-varnishes, paints and linoleum, and for other similar purposes to which oils of this class are applied industrially.

Samples of the nuts were submitted to brokers, who stated that the *kernels* would meet with a ready sale at £12 to £13 per ton (October, 1906.)

MAURITIUS.

A sample of unshelled candle nuts was received from Mauritius in April, 1911. About 18 per cent. of the nuts contained shrivelled or decomposed kernels. Those in good condition were composed approximately of shell 64 per cent. and kernel 36 per cent. The sound kernels yielded 68·1 per cent. of pale, brownish-yellow liquid oil.

The oil had the following constants:—

	Present sample from Mauritius.	Previous sample from Hong Kong.
Specific gravity at $\frac{15·5° C.}{15·5° C.}$ ...	0·927	0·927
Saponification value	193·7	204·2
Iodine value	151	139·7

A large firm of oil-seed crushers, to whom these candle nuts were submitted, reported that the oil expressed from the kernels would probably be worth about £28 to £30 per ton in Europe. The residual cake is of some small value as a fertiliser, and might be worth from 30s. to £2 per ton (October, 1911). The shells of the nuts are of no commercial value, and for that reason the nuts should be shelled and the kernels alone exported.

PARA RUBBER SEED.

STRAITS SETTLEMENTS AND FEDERATED MALAY STATES.

Specimens of Para rubber seed and of meal prepared from them were forwarded to the Imperial Institute in 1902 from the Straits Settlements and the Federated Malay States, and the results of their examination are given in the following report:—

The kernels constituted about 50 per cent. by weight of the whole seeds. On extraction with light petroleum they yielded 42·3 per cent. of oil.

The oil was clear, of light yellow colour, and had an odour somewhat resembling that of linseed oil. It belonged to the class of drying oils, and yielded a clear, transparent film when allowed to dry by exposure to air. The following table gives the constants found for the oil, those of linseed oil being added for comparison:—

	Oil from kernels of Para rubber seed.	Linseed oil.
Specific gravity at 15° C.	0·9302	0·931— 0·937
Free fatty acids—		
Acid value	10·7	—
Calculated as oleic acid, *per cent.*	5·4	—
Ester value	195·4	—
Neutral oil, *per cent.*	94·6	95·5—99·6
Saponification value	191·8	190—195
Iodine value	128·3	170—194

On saponification with caustic soda, the oil yielded a soft soap of yellowish colour.

Para Rubber Seed Meal.—The sample consisted of about 7 lb. of finely ground meal of pale buff colour; it was free from husk, and possessed a pleasant odour.

On extraction with light petroleum, the meal yielded 36·1 per cent. of an oil which had a slightly rancid odour, and, on standing, solidified as a soft, crystalline, yellow mass. It furnished the following constants:—

Specific gravity at 15° C.	...	0·911
Free fatty acids—		
	Acid value ...	130·5
	Calculated as oleic acid per cent.	65·6
Neutral oil	per cent.	34·4
Ester value	... ...	65·2
Saponification value ...	... ...	195·7
Iodine value	... ...	136·2

When heated, the oil began to melt at 19° C., and was a clear liquid at 28° C. It had very marked drying properties, and yielded a solid, transparent film. On saponification with caustic soda, the oil furnished a rather soft soap of a yellowish colour.

In the following table, the constants and properties of the oil extracted from this sample of meal are contrasted with those of the oil obtained from the freshly crushed kernels; the constants of linseed oil are again added for comparison.

—	Oil extracted from Para rubber seed meal.	Oil extracted from Para rubber seed kernels (freshly crushed).	Linseed oil.
Yield of oil ... per cent.	36·1	42·3	33–38
Physical state	Solid below 19° C.	Liquid at 15° C.	Liquid at 15° C.
Specific gravity at 15°/15° C.	0·911	0·9302	0·931–0·937
Free fatty acids (calculated as oleic acid) per cent.	65·6	5·4	—
Iodine value	136·2	128·3	170–194

It will be observed that the oil extracted from the meal was solid, whereas that obtained from the freshly ground seed was liquid. The difference is due to the large proportion (65·6 per cent.) of free fatty acids present in the former, whilst the latter contained only 5·4 per cent. of free acids. The cause of this difference in the two oils has been investigated, and it has been found that after the seed has been crushed the oil gradually undergoes decomposition, owing to the action of a hydrolytic enzyme (lipase) contained in the seed.

The meal furnished the following results on analysis:—

	Per cent.
Moisture	9·1
Ash	3·53
Fibre	3·4
Fat	36·1
Proteins	18·2
Carbohydrates	29·67

The ash was found to contain 30·3 per cent. of phosphoric acid (calculated as P_2O_5) present in the form of phosphates, which is equivalent to 1·07 per cent. of phosphoric acid in the meal.

The results of this examination of the Para rubber seed meal indicate that the material thus prepared could neither be used as a feeding stuff, owing to the presence in it of large quantities of free fatty acids, nor for the expression of oil since the latter has been largely decomposed. It is probable, however, that if the oil were expressed from the fresh kernels, the residual cake could be utilised as a feeding material, as is shown by the following comparison between the calculated composition of such a cake and the composition of some commercial feeding cakes:—

—	Moisture.	Ash.	Proteins.	Fibre.	Fat.	Carbo-hydrates.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent	Per cent.
Para rubber seed cake ...	13·36	5·19	26·81	5·00	6·00	43·64
Linseed cake	11·16	5·20	29 50	9·10	9·50	35·54
Cotton-seed cake (decorticated).	9·0	7·10	43 78	5·18	11·38	23·56

These figures show that a cake prepared from Para rubber seed kernels would compare favourably with other cakes as a cattle food, and would contain a particularly low proportion of indigestible matter (fibre).

Commercial Value of the Kernels and Oil.—Specimens of both the kernels and oil were submitted to leading brokers. They reported that the oil could probably be used as a substitute for linseed oil and would be worth about 20*l.* per ton, but that oil merchants would not take it up unless they first had an opportunity of testing it in bulk. The brokers considered that it would be more profitable to ship the kernels themselves to this country, as is done in the case of most other oil-seeds. They valued the kernels at 10*l.* to 12*l.* per ton, and added that they would be prepared to take two or three tons at the lower price in order to introduce them into the market (1903).

The Para rubber seed meal was not commercially valued, since in its present condition it could not be utilised in any way. Para rubber seed "cake" of the composition already given should be almost as valuable as linseed cake, which sells at from 5*l.* 15*s.* to 6*l.* 15*s.* per ton (1903).

The results of this investigation lead to the conclusion that the kernel of the Para rubber tree is a valuable economic product, and is likely to become of considerable commercial importance.

The oil possesses properties very similar to those of linseed oil, and should therefore be suitable for the preparation of paints and varnishes, and for the manufacture of rubber substitutes, linoleum and waterproofing materials. It could probably also be used like linseed oil for the manufacture of soft soap. The cake left after expressing the oil from the shelled seeds (kernels) would probably be of value as a cattle food, since its calculated composition compares very favourably with the various cakes at present in use, and it is stated that animals readily eat the kernels in the Straits Settlements.

The results obtained in this investigation of Para rubber seed have since been confirmed by the examination of a number of further samples of the seed which have been forwarded to the Imperial Institute.

Para Rubber Seed Oil.

A small consignment of Para rubber seed oil which had been prepared by expression at the Perak Museum was received at the Imperial Institute for examination in 1908. It was stated that the press used was not very efficient, and that the best result obtained was a yield of 34 per cent. of oil from the dried kernels.

The oil was light brown, slightly cloudy, and deposited a brown muddy sediment. After filtration a bright yellow oil was obtained which gave the following results on examination:—

	Present sample.	Previous sample.
Specific gravity at 15·5/15·5° C. ...	0·925	0·9302
Acid value	16·8	10·7
Saponification value ...	192·1	191·8
Iodine value	131·4	128·3

It will be seen that the constants of the expressed oil agree closely with those obtained for the previous sample of oil which was extracted at the Imperial Institute from the kernels by light petroleum.

Samples of the oil were submitted to manufacturers, who confirmed the opinion, previously expressed, that Para rubber seed oil could be utilised as a substitute for linseed oil. The results of technical trials showed that it could be employed in the manufacture of paints or of soft soap. It is, however, inferior in drying power to linseed oil (as would be expected from its lower iodine value), and would consequently command a lower price (1908).

Para Rubber Seed Cake.

A small quantity of Para rubber seed cake, obtained on expressing the oil from the kernels, was received at the Imperial Institute for examination in 1911 in order to determine its suitability for use as a feeding-stuff for cattle.

The cake was fairly soft, and arrived in a very broken condition, much powder being present.

An analysis furnished the following results:—

	Per cent.
Moisture	6·91
Crude proteins	29·93
Consisting of:	
True proteins	27·03
Other nitrogenous substances...	2·90
Fat	17·68
Starch, &c. (by difference)	35·97
Fibre	4·82
Ash	4·69

Nutrient ratio:—1 : 2·56.

(The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.)

Food units:—155

(The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.)

The cake did not contain saponin nor any alkaloid; if any cyanogenetic glucoside were present the amount was less than that necessary to yield 0·01 per cent. of hydrocyanic acid.

It will be seen from the following table that this Para rubber seed cake compares very favourably in composition with the feeding cakes in common use:—

—	Para rubber seed cake.	Soy bean cake. English.	Soy bean cake. Imported.	Linseed cake. Average English.	Linseed cake. American.	Cotton-seed cake. Average decorticated.	Cotton-seed cake. Undecorticated. English.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	6·91	12·70	17·00	11·16	9·30	9·00	13·75
Crude proteins ...	29·93	38·82	40·50	29·50	33·37	43·78	24·62
Fat	17·68	11·07	9·00	9·50	10·06	11·38	6·56
Carbohydrates (by difference)	35·97	26·51	23·78	35·54	31·84	23·56	29·28
Fibre	4·82	5·85	4·47	9·10	10·37	5·18	21·19
Ash	4·69	5·05	5·25	5·20	5·06	7·10	4·60
Food units... ...	155	151	147	133	140	161	107

The present sample of Para rubber seed cake contains more fat than is desirable, and it would be advantageous to submit the kernels to greater pressure in order to extract more of the oil and thus produce a harder cake.

Feeding Trials.

Feeding trials were conducted for the Imperial Institute with this cake on cows and sheep, and the following report was furnished:—

A quantity of the cake was moistened with water and fed to cows. All, except three which are usually averse to new foods, ate it readily. The dry and powdery condition of the cake suggested the moistening of it before feeding, and it was found that it absorbed its own weight of water, and was then more appetising than when fed dry. Several cows refused it in the dry state, and ate it readily when moist. Three cows received the cake daily for five days, getting 4 lb. each day. They all ate it readily, and no scouring or binding effects were noticeable, nor did the milk or cream appear affected in any way.

The cake was fed in the dry state to sheep and was eaten fairly readily. Some sheep ate their full allowance when it was mixed with other foods, but apparently had less liking for it when fed alone. No exceptional effects were noticed.

A more extended trial with a larger number of animals and a larger daily allowance of the cake would be necessary before the safe limits and effects of this food could be stated.

The results of these trials are satisfactory so far as they go, but, as stated above, it will be necessary to conduct trials extending over a much longer period before a really useful opinion as to the feeding value of Para rubber seed cake can be formed. For results of further trials see *Bull. Imp. Inst.* (1913, **11,** 551).

The Utilisation of Para Rubber Seed.

Since the kernels of Para rubber seed were first investigated at the Imperial Institute in 1902-3, small consignments have been received from time to time in London and sold as oil-seeds, but there has been no large development of this trade, mainly because the demand for seed for planting has been so large as to preclude the collection of seed for industrial use, and, further, the profits from sales of rubber on developed estates have been so large in recent years that little or no attention has been given to the utilisation of by-products. Now, however, when the area of productive Para rubber plantations is increasing rapidly every year, it seems likely that this indifference to the possibility of using these kernels will disappear, and already the expression of oil from the kernels has been undertaken at one or more mills in the East Indies.

It is opportune, therefore, to call attention to several practical difficulties which may occur in dealing with these kernels, and to methods of overcoming them.

Considerable difference of opinion exists as to the cost of collecting Para rubber seeds. The late Mr. Carruthers, in his report as Director of Agriculture for the Federated Malay States in 1908, estimated that 1,000 seeds could be collected there for 4 cents (1·1*d.*), and that 414,400 seeds would be needed to produce 1 ton of kernels. From these data he calculated that the cost of collecting and shelling 1 ton of kernels would be \$21·14 (\$1=2*s.* 4*d.*).

This estimate is considered far too low by Messrs. Macmillan and Petch (*Journ. d'Agric. Trop.*, 1910, 10, 284, and *Circulars and Agr. Journ., Roy. Bot. Gard., Ceylon,* 1908, 4, 90), who

point out that in Ceylon the cost of collecting 1,000 seeds is 4d., and that Mr. Carruthers' estimate of the number of seeds required to produce 1 ton of kernels is based on the weight of seeds from untapped trees. It has been shown in Ceylon that seeds from tapped trees are smaller and lighter than those from untapped trees, and Messrs. Macmillan and Petch estimate that from tapped trees at least 700,000 seeds would be needed to produce 1 ton of kernels. Accepting their data, the cost of collecting sufficient seed to produce 1 ton of kernels would be £11 13*s*. 4*d*., which is certainly a prohibitive price so far as the export of these kernels as an oil-seed is concerned. It should be pointed out that Messrs. Macmillan and Petch's criticism of Mr. Carruthers' estimate is mainly directed to the question of the quantity of seeds required to produce 1 ton of kernels, whereas the principal difference between the two estimates lies in the cost of collection, which appears to be nearly four times as great in Ceylon as in the Federated Malay States. In this connection it may be mentioned that Mr. Ridley, Director of the Botanic Gardens, Singapore, has suggested that the right of seed collection in plantations in the Straits Settlements might be leased to Chinese, who would be able to utilise for this purpose the labour of village children. If this plan is feasible it would appear to afford a comparatively simple solution of the labour difficulty in Malaya.

For shelling the seeds, the installation of machinery is desirable. Trials with Miller's nut-cracking machine at the Imperial Institute have shown that this can be used for the purpose; but it is necessary that trials on a comparatively large scale with the various machines available should be made before definite recommendations in favour of any one make are made. It is essential that the machine adopted should crack the shells without damaging the kernels, since the latter deteriorate somewhat rapidly when they are broken and exposed to air. This is of small importance when the kernels are to be utilised locally and at once for the expression of oil, but it becomes all-important if the kernels are to be exported.

Kernels for export should be thoroughly dried in the sun before being packed in bags for shipment. When these precautions are taken it is quite clear that the kernels can be shipped to Europe, and will arrive in sound condition. In 1909 a small experimental shipment was made to this country from Ceylon and it behaved quite satisfactorily on expression and furnished oil of excellent quality. In 1911 a further small shipment of kernels was received at Liverpool, and a sample of these, kindly supplied to the Imperial Institute by the purchasers, was found to be in good condition, and to give a normal yield of oil of good quality.

In expressing Para rubber seed oil trouble may arise from the presence of a fat-splitting enzyme in the kernels, as this is taken out with the water expressed along with the oil, and if this aqueous layer is left in contact with the oil, the latter will be hydrolysed into glycerine and fatty acids. A similar fat-splitting enzyme, however, occurs in castor seed, and this occasions no difficulty in the industrial preparation of castor oil

and it may be assumed that with due care no trouble will arise with Para rubber seed kernels from this cause. The kernels should, however, be kept unbroken and should be expressed as soon as possible after shelling, in order to avoid possible deterioration of the oil before expression.

In determining the value of an oil-seed the amount of oil present is the factor of prime importance, but much also depends on the nature of the cake left after expression of the oil. If this contains no deleterious ingredients and is rich in nutritive materials and poor in indigestible fibre, it can be used as a feeding-stuff for cattle, but if deleterious ingredients are present the material can, as a rule, only be employed as a manure. Unfortunately Para rubber seed kernels contain a cyanogenetic glucoside and an enzyme which decomposes this in the presence of water, yielding prussic acid as one product. This, however, is also true of linseed cake, perhaps the most popular feeding-stuff with farmers in this country at the present time, so that the mere production of small quantities of prussic acid affords no ground for suggesting that cake from Para rubber seed kernels will be unsuitable for feeding cattle. It is, however, of the greatest importance to determine as soon as possible what the average maximum yield of prussic acid from cake made from these kernels under industrial conditions is, and if this proves to be no larger than that obtained from linseed cake on the average, it may be assumed that the cake is worth trial as a feeding-stuff. With all new feeding-stuffs it is desirable that extensive preliminary feeding trials should be made before the material is placed on the market, and even should Para rubber seed cake prove to yield less prussic acid than average linseed cake, it will still be indispensable that feeding trials should be made with it. The preliminary trials referred to on page 454 have given promising results but require to be supplemented by experiments on a larger scale.

A detailed examination of Para rubber seed oil has been made in the Scientific and Technical Department of the Imperial Institute, and the results are given in a paper by S. S. Pickles, D.Sc., and W. P. Hayworth, F.I.C., which has been communicated to the Society of Public Analysts (*Analyst*, 1911, **36**, 491). The results show that the oil consists of a mixture of glycerides of linolenic, linoleic, oleic, and stearic acids, with possibly some palmitic acid.

The proportion of unsaturated acids present is lower than in linseed oil, as was to be expected from the slower "drying" character shown by Para rubber seed oil.

CEARA RUBBER SEED
(*Manihot Glaziovii*).

UGANDA.

A sample of Ceara rubber seeds from Uganda was received in March, 1909. The seeds resembled castor seed in outward appearance, but differed from them in having a thick, hard, woody shell

and firm nut-like kernels. They were found to consist of 75 per cent. shell and 25 per cent. kernel, and only yielded 12 to 13 per cent. of dark yellow, liquid oil, calculated on the whole seeds. The kernels were extracted from the seeds with difficulty, as on splitting the hard shell the kernel generally broke also. The oil furnished the following figures (column 1 in table) on chemical examination, to which are added for comparison (column 2 in table) the figures for an analysis of the oil by Fendler and Kuhn (*Ber. deut. Pharm. Ges.*, 1906, **15**, 426) and of Para rubber seed oil, examined at the Imperial Institute:—

	Ceara rubber seed oil. (1)	Ceara rubber seed oil. (2)	Para rubber seed oil.
Specific gravity at 15/15° C.	0·926	0·926	0·925–0·930
Acid value	0·8	2·18	10·7–16·8
Saponification value	193·0	188·6	191·8–192·1
Iodine value	140·0	137·0	128·3–131·4
Reichert-Meissl value...	—	0·7	—
Unsaponifiable matter	—	0·9	—

The above analyses show that the oil is a drying oil, somewhat similar to Para rubber seed oil. It does not appear likely that Ceara rubber seed would prove a remunerative source of oil, as the seeds are difficult to shell, and the proportion of hard shell is too large to allow of their use in an unshelled condition for the expression of oil.

"NSA-SANA" SEED KERNELS.

Southern Nigeria.

This sample of "Nsa-Sana" kernels, from the Calabar district of Southern Nigeria, was forwarded for examination to the Imperial Institute in June, 1906.

No information was received as to the botanical source of the kernels, but from enquiries subsequently made in Southern Nigeria by the Principal Forestry Officer, it appears that they are the product of *Ricinodendron africanus*, Muell.

The sample consisted of about 3½ lb. of the kernels, which were in fair condition on arrival.

The kernels were found to contain 45·2 per cent. of oil, which dried in a day on exposure to air at the atmospheric temperature, and left a wax-like residue.

The oil has been examined chemically and found to resemble tung oil (Chinese wood oil) in composition (see p. 448). The following table gives the results obtained in the examination of

the oil from the nsa-sana kernels and also the constants of tung oil for comparison:—

	Oil from Nsa-Sana kernels.	Commercial tung oil.
Specific gravity	0·9320 (at 20° C.)	0·933–0·942 (at 15·5° C.)
Saponification value ...	191·6	190–197
Iodine value	147·7	149–165
Hehner value	95·2	96·3
Titer test	35·7° C.	37·1°–37·2° C.

These results, and the behaviour of the oil on drying, seem to show that the oil from nsa-sana kernels could be utilised as a substitute for tung oil; but technical trials would be necessary in order to determine this point. Tung oil is principally sold in the United States of America, but there is also a fair market in this country, where it is used in the manufacture of linoleum and also in lacquer and varnish making. The price of tung oil in London at the date of the report (Feb., 1907) was from £32 to £33 per ton.

The nsa-sana oil could also be utilised for making soft soap, and it would be worth from £18 to £20 per ton for this purpose (Feb., 1907). The value of the kernels would be determined by the amount of oil they contain and the price obtainable for it.

The "cake" left after the extraction of the oil resembled decorticated cotton-seed cake in composition but on examination for poisonous constituents indications of the presence of an alkaloid were observed. On this account, and also owing to the nature of the oil which the kernels contain, it seems improbable that the cake could be used as a cattle food, and very careful experiments as to its effects on animals would first have to be made before it could be recommended for this purpose. It could, however, be utilised as a manure, since it is rich in nitrogen.

A sample of unshelled nsa-sana seeds was received from Southern Nigeria subsequently.

It consisted of small rounded nuts, dirty brownish-grey in colour. The shells were very hard and thick, and possessed a bright white internal coating. The kernels, which were white and soft and could not be freed easily from the shells, formed 29 per cent. and the shells 71 per cent., by weight, of the whole seeds. The material received previously consisted of kernels only.

The yield of oil was 47·0 per cent. expressed on the kernels, or 14 per cent. expressed on the entire nuts. It was light yellow in colour, with a pleasant taste resembling ground-nut oil, and dried to a film in a few hours. It gave the following results on examination:—

	Present sample.	Previous sample.
Specific gravity	0·934	0·932
Acid value	1·2	—
Saponification value ...	184·7	191·6
Iodine value	148·2	147·7
Hehner value	94·1	95·2
Reichert-Meissl value ...	1·9	—
Unsaponifiable matter ...	1·2	—
Titer test	34·5° C.	35·7° C.

A large sample of the seeds was submitted to a firm of varnish manufacturers, who, after conducting experiments with the oil, reported that in their opinion it would prove a welcome addition to the list of oils useful to the varnish maker. They stated that the oil from the Ricinodendron seeds stands intermediate in properties between tung oil and linseed oil, and would be superior to the latter for many purposes. They further stated that if this oil could be produced cheaply on a commercial scale it would compete with tung oil.

Large quantities of these nuts are stated to be available in certain districts of Southern Nigeria, but it seems doubtful whether they could be exported profitably from West Africa for the following reasons:—

1. The low proportion of kernel in the nut, and the great difficulty of separating the kernels.
2. The low yield of oil from the entire nuts (14 per cent.).
3. The cake is probably of no value except as a manure.
4. Regarding the oil as equal in value to tung oil (£30 per ton), the market price of the unshelled seeds would not exceed £4 10*s*. per ton in this country, which, according to the figures given by the Forest Officer at Benin, would probably not pay for the cost of collection.

If, however, means could be found of freeing the kernels from the shells in order to reduce the cost of transport, there is little doubt that the kernels would find a ready sale in this country, and that the oil would be at least as valuable as linseed oil, which at the date of the report was worth £21 12*s*. 6*d*. to £21 17*s*. 6*d*. per ton.

SEMI-DRYING OILS.

Oils belonging to this class are generally valued in comparison with cotton-seed oil, which commercially is the most important member of the group. The chief oil-seeds yielding oils of this class imported to the United Kingdom are cotton seed, rape seed, and soy beans. In 1910, 690,171 tons of cotton seed, valued at £4,865,863, and in 1911, 596,959 ons, valued at £4,398,675, were imported into the United Kingdom, chiefly from India and Egypt; the following quantities of cotton-seed oil were also imported: 1910, 16,852 tons, valued at £585,656; 1911, 25,466 tons, valued at £811,054. The total exports of cotton seed from India in 1909-10 were 282,491 tons, valued at £1,354,531; and in 1910-11, 299,011 tons, valued at £1,530,173. The total exports of cotton seed from Egypt were 319,229 tons, valued at £2,216,243, in 1910; and 455,879 tons, valued at £3,118,116, in 1911. The United States is the largest cotton seed producing country, but comparatively little seed is exported, most of it being expressed in the country. In the year ending June 30, 1911, 100,679 tons of cotton-seed oil, valued at £3,568,202, were exported from the United States, and only 5,903 tons of cotton seed, valued at £43,738.

The trade in rape seed and rape-seed oil is also considerable. In 1909-10, 331,466 tons of rape seed, valued at £3,122,161, were exported from India, and in 1910-11, 329,652 tons, valued at £3,104,296. The imports of rape seed to the United Kingdom in 1910 and 1911 were as follows: 251,324 qrs., valued at £443,530, and 232,199 qrs., valued at £431,376, respectively; the corresponding figures for rape-seed oil in the same years were: 13,489 tons, valued at £359,166, and 8,408 tons, valued at £246,193.

The chief point of interest in oils of this class is the enormously rapid increase of the imports of soy beans to the United Kingdom during the last few years. Until the end of 1908 practically no imports of this oil-seed were recorded, whilst in the 1908-9 season 410,000 tons were exported from Vladivostok and Dairen alone, and of this quantity all but 5,000 or 6,000 tons went to the United Kingdom. In 1910 the total imports of soy beans into the United Kingdom were 421,531 tons, valued at £3,047,048, but in 1911 the imports fell to 222,657 tons, valued at £1,652,383. For further information see the "Bulletin of the Imperial Institute" (1909, **7**, 308 and 1910, **8**, 40).

Another important oil-seed yielding a semi-drying oil is sesamum seed, of which 149,182 tons, valued at £1,772,767, were exported from India in 1909-10, and 162,327 tons, valued at £2,135,539, in 1910-11. The greater part of the sesamum seed produced is expressed at Marseilles and does not seem to be imported to the United Kingdom for use as a source of oil, although small quantities are used in the preparation of compound feeding cakes.

COTTON SEED.

NYASALAND.

This sample of Upland cotton seed was received from Nyasaland with a request for information as to whether it could be profitably exported.

The seed contained a considerable quantity of lint, which would render it unsatisfactory for use in an oil mill. If the seed were ginned more carefully in the first instance, or ginned a second time in order to clean it more thoroughly, it would probably be saleable in the United Kingdom at about the same price as East Indian cotton seed, which was worth £6 5*s.* to £6 10*s.* per ton at the date of the report (February, 1910).

COTTON-SEED OIL.

The following report relates to two samples of cotton-seed oil which were examined in connection with an investigation into the possibility of preparing edible fats from Indian cotton-seed oil, to be used in India as substitutes for "ghi" (butter fat).

The first sample was prepared from Indian seed, the second from Egyptian seed; both samples were refined before examination.

	Refined oil from Indian seed.	Refined oil from Egyptian seed.
Specific gravity at $\frac{15{\cdot}5^\circ \text{C.}}{15{\cdot}5^\circ \text{C.}}$	0·923	0·923
Acid value	0·35	0·21
Saponification value ...	193	193
Iodine value	102	109
Titer test	27·0° C.	28·6° C.
Hehner value	96·2	96·2
Unsaponifiable matter ...	0·5 (approx.)	1·0 (approx.)
Colour	Brownish	Yellow
Taste	Not unpleasant; no distinct acrid after-taste.	Not appreciably different from that of the Indian oil.

A little solid flocculent matter separated from both of the oils on standing for several weeks at a temperature of about 19° C.

The above results show that the Indian cotton-seed oil did not differ in composition from the Egyptian cotton-seed oil with which it was compared, and the flavours of the two oils did not differ appreciably. The Indian cotton-seed oil was darker in colour, but it was found possible to reduce the colour to the same shade as that of the Egyptian oil, or to an even lighter shade, by treatment with fuller's earth.

BARBADOS.

A sample of cotton-seed oil was received at the Imperial Institute from Barbados in February, 1906. It was of a yellowish colour, and contained a minute amount of solid matter, which disappeared on heating, and when examined under the microscope was seen to consist of minute crystals. This deposit was too small to examine separately, but it was probably merely "cotton-seed oil stearin."

On chemical examination the oil furnished the following results, to which are added for comparison the usual constants of cotton-seed oil.

	Oil from Barbados.	Usual constants of cotton-seed oil.
Specific gravity at 15° C. ...	0·9226	0·92–0·93
Titer test	31·9°–32·1° C.	32·2°–37·6° C.
Saponification value	196·5	191–196·5
Hehner value	95·07	95·87–96·17
Iodine value	88·5	100·9–116·9
Acid value	0·44	—

It will be seen that the results furnished by this sample of oil from Barbados agree well with the recorded constants of cotton-seed oil except in the iodine value which is much lower than usual. The low iodine value would not interfere with the use of the oil for soap-making, but might arouse suspicions regarding its purity if it were utilised for edible purposes.

SOY BEANS.

HONG KONG.

Four varieties of soy beans were received in July, 1911, as follows:

No. 1.—" White Bean," known locally as " Pak tau." This sample consisted of large, clean, plump, rounded seeds of pale yellowish-brown colour. A few of the seeds were attacked by weevils.

The seeds yielded 18·1 per cent. of oil, which had the usual characteristics of soy bean oil.

The beans were submitted to a firm of oil-seed crushers who valued them at about £8 per ton, net cash, at any English port (February, 1912), and to a firm of brokers, who described them as of similar quality to beans received from Southern Manchuria and also valued them at £8 per ton (February, 1912).

No. 2.—" Green Bean," known by the Chinese as " Tsing tau." These were fairly large, rounded beans, of a pale greyish-green colour externally and yellowish within. Some dirt and a few foreign seeds were present in the sample. They yielded 17·9 per cent. of normal soy bean oil.

The beans were submitted to a firm of oil-seed crushers, who valued them at £8 per ton, net cash, at any English port (February, 1912), and to a firm of brokers, who classed them with beans from Harbin, and valued them at £7 17*s.* 6*d.* per ton (February, 1912).

No. 3.—" Yellow Bean." These beans were somewhat small, round, and yellowish-brown in colour. A good many damaged and shrivelled beans were present in the sample, as well as some dirt. They yielded 16·6 per cent. of normal soy bean oil.

The sample was submitted to a firm of oil-seed crushers, who pointed out that a considerable number of the beans were split, and that a good deal of damage had been done by maggots. The firm valued the beans at about £7 15*s.* per ton, net cash, at any English port (February, 1912), adding that in bulk they would probably arrive in better condition and would then realise the same price as the sample of " white " beans, No. 2. A firm of brokers described them as of fair qualily and worth £7 17*s.* 6*d.* per ton (February, 1912).

No. 4.—" Black Bean." This sample consisted of flat beans, with black skin and yellow endosperm. Some impurity was present in the form of foreign seed and dirt. The yield of oil in this case was 15·1 per cent.

The somewhat low percentage of oil yielded by these beans, and the black colour of the seed-coat, make them less valuable than the preceding samples of " white," " green," and " yellow " beans, and they were valued by the firm of oil-seed crushers who examined the previous samples at £7 10*s*. per ton (February, 1912). A firm of brokers valued them at about £7 12*s*. 6*d*. to £7 15*s*. per ton (February, 1912).

A firm of oil-seed crushers to whom the samples of soy beans were submitted stated that the amount of moisture present was in all cases just over 8 per cent., which is considerably less than that in the Manchurian beans commonly imported into Europe. These Hong Kong beans would undoubtedly be preferred from this point of view, and there would also be less risk of damage during transit than in the case of beans containing a higher percentage of moisture.

Wei-hai-wei.

Two small samples of soy beans grown at Wei-hai-wei were sent for examination in June, 1909.

No. 1.—Pale green beans marked with brownish patches; contained 17·1 per cent. of oil.

No. 2.—Pale buff-coloured beans smaller than the green variety; contained 17·0 per cent. of oil.

These beans do not differ in yield from ordinary commercial shipments of soy beans, the percentage of oil recorded by various observers being from 15·8 per cent. to 18·9 per cent., 18 per cent. being fairly common.

Ceylon.

" Soy beans grown at Jaffna from seed imported from Java."

The sample consisted of small black seeds, mixed with some brown immature seeds and a quantity of tea leaf. It yielded 14·5 per cent. of oil. Yields of from 13·3 to about 22 per cent. have been recorded for soy beans, the usual amount being about 18 per cent.

The oil possessed the normal characteristics of soy bean oil. The current price of soy beans at Hull was £8 13*s*. 9*d*. per ton (August, 1912). The present sample would not realise such a high price, owing to the dark colour of the seeds and their small size, the low yield of oil, and the presence of foreign material.

It would be advisable to cultivate in Ceylon the more valuable ordinary yellow commercial variety of soy bean, in preference to this black, small-seeded kind.

Sierra Leone.

The samples of soy beans which are the subject of this report were forwarded to the Imperial Institute in January, 1911. The

beans were stated to have been grown at the Station, Headquarters, and Kebe Town farms in the Ronietta district, and it was desired to ascertain their value on the English market.

(1.) "Station Farm, sown in drills."

Brown or blackish pods, containing in most cases two or three beans, but occasionally only one. The beans were of medium size and buff colour; some of them were marked by brownish stains and a number of dark brown and black beans were present. A good many of the beans were rather shrivelled.

(2.) "Station Farm, sown broadcast."

These pods and beans were similar to the preceding sample 1.

(3.) "Headquarters Farm, sown broadcast."

The pods in this sample were rather lighter in colour than those of sample 1, but the beans were similar to those described above.

(4*a*.) "Kebe Town Farm, in drills."

Pods and beans similar to those of sample 1.

(4*b*.) "Kebe Town Farm, broadcast."

The pods in this sample resembled those of sample 1, but the beans were mostly of somewhat better appearance than those of all the foregoing samples, being less shrivelled and of clean buff colour. Some brown and black beans were also present.

The samples were examined with the following results:

—	No. 1.	No. 2	No. 3.	No. 4a.	No. 4b.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Beans	61	63	63	65	64
Husk	39	37	37	35	36
Proportion of good beans by weight (approx.)	95	97	97	96	97
Moisture in beans ...	10·1	16·0	9·1	10·4	10·5
Oil in beans :—					
As received	20·6	22·3	23·6	21·8	20·8
In beans dried at 100° C.	22·9	24·8	25·9	24·3	23·3

For comparison with these figures it may be stated that soy beans of commerce contain, as a rule, about 18 per cent. of oil in the air-dry beans or about 20 per cent. in the beans dried at 100° C. The present samples therefore contain a very satisfactory percentage of oil, being from 2·6 to 5·6 per cent. richer in oil than average soy beans as imported from Manchuria.

The current market price in London of soy beans of good quality is over £7 per ton (March, 1911), and beans similar to the present sample would realise this price, if shipped free from the pods and properly prepared so as to avoid a shrivelled and stained appearence.

SOY BEAN OIL.

Hong Kong.

This was a clear, brownish-yellow oil, which furnished the following results on examination:

Specific gravity at $\frac{15\cdot5^{\circ}\ C.}{15\cdot5^{\circ}\ C.}$	0·924
Acid value	2·5
Saponification value	193·8
Iodine value	130·0

The sample was submitted to a firm of oil merchants, who valued it at £23 5*s*. per ton, in Hull, as a normal soy bean oil. Brokers valued it at 23*s*. 6*d*. per cwt. in London, packed in cases (February, 1912), adding that it represented the finest quality of Hong Kong soy bean oil.

SESAMUM SEED.

SUDAN.

No. 1.—" Sim-sim (sesame) seed, known locally as ' eirawi,' from the Gedaref district of Kassala Province." This sample consisted of white sesamum seed, mixed with 3·5 to 4·0 per cent. of extraneous matter, which could be removed by sifting. The clean seed contained 4·7 per cent. of moisture, and yielded 51·0 per cent. of oil. This yield of oil is normal and satisfactory. The oil had the usual appearance of sesamum seed oil.

The sample, after cleaning, was submitted to brokers, who stated that it was superior to the fair average grade of sesamum seed. They valued it at about £17 per ton delivered at European ports (May, 1912), with large white Bombay seed at £19 per ton, and yellow Chinese at £18 7*s*. 6*d*. per ton.

No. 2.—" ' Eirawi ' sim-sim seed from the Gedaref district of Kassala Province." This consisted of white seed, mixed with a small quantity of extraneous matter. The clean seed yielded 51·2 per cent. of oil, which is normal and almost identical with the yield from the previous sample from the Gedaref district. The oil possessed the normal characters of sesamum seed oil.

The seed was submitted to brokers, who stated that it was of very good quality and valued it at £17 10*s*. per ton, delivered at European ports (August, 1912), with large white Bombay seed at £17 17*s*. 6*d*. per ton.

ABYSSINIA.

The sample consisted of a mixture of white and brown seeds and was stated by the brokers to be equal to 50 per cent. " white Bombay seed." It was valued at £11 to £11 10*s*. per ton, provided that not more than 3 per cent. of dirt is present (March, 1906).

RHODESIA.

This sample of sesamum seed, known locally as " Luganca " or " Ndongea " seed, from Southern Rhodesia was sent by the British South Africa Company to the Imperial Institute for examination. The seed is said to be cultivated by the natives, who use it in small quantities for food and also anoint their bodies with the oily pulp obtained on pounding the seed.

The sample consisted of 2 oz. of seed, which varied in colour from pale buff to dark brown; it was clean and free from dirt and foreign seeds.

The sample was submitted for valuation to brokers, who stated that it was equal in quality to Coromandel Bigaree Sesamum seed, January crop, the current value of which at the time of the report was £12 7*s.* 6*d.* per ton c.i.f. delivered in London (January, 1907). They added that large quantities of the seed could be disposed of at this price.

Another sample of 4 oz. of clean white sesamum seed was received from Rhodesia and submitted to brokers for valuation, who stated that consignments of similar character would be worth £14 per ton c.i.f. delivered at Marseilles for November-December shipments (October, 1908).

Northern Nigeria.

This sample was received at the Imperial Institute in 1909. It weighed 12 oz. and consisted of a mixture of black, brown, and white seeds. The sample was clean and free from admixture of other grain, and yielded 45·2 per cent. of oil, a rather lower proportion than is usually obtained from sesamum seed.

The seed was submitted to brokers, who reported that it represented a fair quality, but that it was somewhat damaged, and as sesamum oil is used for edible purposes, this fact would materially affect the value of the sample. The firm stated that it is easier to sell this product in continental ports than in the United Kingdom, and valued the sample at 40*s.* per 384 lb., less 3½ per cent., delivered ex ship (December, 1909).

It is usual on the Continent to employ the finer qualities of the oil, obtained in the first expression, in the manufacture of edible oils and fats, whilst the oil from the second and third expressions is used for other purposes, chiefly for soap-making. In the United Kingdom, however, the whole of the oil would have to be disposed of for soap-making, and for this reason the seed cannot realise such a high price as it does on the Continent.

SUNFLOWER SEED.

Sudan.

This sample of sunflower seed was forwarded from the Sudan in January, 1911.

The seeds were small and white, having the usual shape and appearance of sunflower seeds. The sample contained some dust, vegetable debris, and immature seed, which could be removed by sifting. An average sample from the consignment, including the small immature seeds, consisted of husk 54 per cent., and kernel 46 per cent. The kernels yielded 47·9 per cent. of oil, equivalent to about 22 per cent. on the whole seeds. The oil was somewhat viscous and of bright yellow colour, becoming rather cloudy on standing. It had a slight smell and taste.

The constants of the oil, compared with results previously recorded, were as follows:—

	Oil from present sample of seed.	Results recorded for sunflower seed oil.
Specific gravity at 15°/15° C. ...	0·921	0·924 to 0·936
Acid value	4·5	not recorded.
Saponification value	188·8	188 to 194
Iodine value	102·5	119·7 to 135
Titer test	16·6° C.	17° to 18° C.

The constants given above for the oil yielded by this Sudan seed agree with those recorded for sunflower seed oil, except the iodine value, which is lower than the figures usually given. This, however, may be due to the previous results having been determined on commercial samples of the oil which had possibly been "demargarinated." Further, the oil, on account of its iodine value, is usually stated to be a "drying" oil, but on the results now recorded it would be classed as a "semi-drying" oil, and experiments made at the Imperial Institute showed that the oil from the Sudan seed only dried very slowly on exposure to the air in thin films.

The seed was submitted to several firms of commercial experts, including oil-seed crushers and manufacturers of edible fats.

The oil-seed crushers stated that sunflower seed has very seldom been crushed in the United Kingdom, but that it is extensively grown and crushed in Russia, where the seed is decorticated before crushing in order to improve the quality of the oil. The resulting cake finds a large market in Northern Europe as a feeding-stuff, but is very little used in the United Kingdom.

One of the firms reported that the sample of Sudan sunflower seed appeared to be rather old and dry, whilst the seed was light and likely to yield a cake containing a high percentage of woody fibre. They valued it at about £8 per ton delivered in Hull or London (July, 1911), adding that fresh seed of heavier quality would realise a higher price.

Another firm stated that the yield of oil given by this Sudan seed agreed well with previous results recorded for sunflower seed, and that the seed could be classed for crushing purposes with soy beans and cotton seed.

Makers of edible fats reported that the oil obtained from the kernels is fairly sweet and neutral, and would probably be suitable for edible purposes, whilst the residual cake appears to be a good feeding-stuff. The unrefined oil would compete with cheap nut-oils and cotton oil, and the refined product would make a good substitute for olive oil. The firm considered that for these purposes the seed would have to be imported at a low price, and in a decorticated condition, as the shell forms nearly 50 per cent. of the whole seed and would greatly increase the cost of shipment. They stated that they would be interested to receive offers of the decorticated seed.

MAHOGANY SEED OIL.

BARBADOS.

A small sample of mahogany seed oil was received from Barbados in March, 1911.

The oil was clear, dark greenish-yellow in colour, with an odour resembling that of linseed oil and an unpleasant bitter taste.

It was examined with the following results:—

Specific gravity at 15·5°/15·5° C. ...	0·935
Acid value	13·0
Saponification value	193·3
Iodine value	125·0
Titer test	30·5° C.
Hehner value	93·7
Reichert-Meissl value	1·9

The oil dried very slowly on exposure to the air.

The sample of the oil forwarded for examination was too small to enable any technical trials to be made, but specimens were submitted for valuation to soap and varnish manufacturers. The soap-makers reported that this mahogany seed oil resembles soy bean oil, and that it could not be used to replace cotton-seed oil in the manufacture of hard soap. Consequently its value would not be equal to that of cotton-seed oil. The oil could, however, be employed for making soft soap. The varnish-makers considered that the oil could be utilised for mixing with paints, &c., but they pointed out that it dries slowly in comparison with linseed oil, and that, in order to arrive at definite conclusions, a practical trial of some duration would be necessary. It is probable that this oil would realise about the same price as soy bean oil, viz., £26 per ton (July, 1911).

M'FUCUTA SEED KERNELS.

Mozambique.

A small sample of seeds was received from the Mozambique Company labelled "Sementes de Arvore, 'Fucuta, Colhida em Cheringoma." The seeds were typically euphorbiaceous in shape and structure, and about the size of large castor oil seeds. The kernels were covered with a thin papery skin of a pale grey colour with reddish markings.

The kernels contained 50·97 per cent. of a deep yellow-coloured oil which was practically odourless. It had no marked taste, but after a time produced a persistent irritant effect on the tongue.

Specific gravity at 16°/16° C.	0·9264
Acid value	7·76
Saponification value	188·8
Iodine value	118·7
Titer test	23·8° C.
Hehner value	95·4
Reichert-Meissl value	0·40

The oil dried to a clear film on glass in from 9 to 10 days. The sample of seed was so small that no technical trial of the oil could be made and therefore no definite information as to its value could be given.

In response to a request for further material a larger sample was forwarded in May, 1909. It was labelled "M'fucuta seeds from Cheringoma," and consisted of brown, thin-shelled seeds, about 0·8 inch long and 0·6 to 0·7 inch wide, somewhat resembling castor oil seeds, but larger and having a dull surface. The shells were fairly easily broken, but the kernels were soft and liable to be damaged in the process. Many of the seeds contained no kernels, but good specimens consisted of 60 per cent. kernel and 40 per cent. shell.

The kernels contained 46·4 per cent. of oil, corresponding to 28 per cent. (approx.) in the whole seed, slightly below the amount found in the first sample (see above). The oil was of bright, dark-yellow colour, semi-drying, tasteless at first but producing after a time an unpleasant burning sensation in the mouth. It furnished the following results on chemical examination:—

Specific gravity at 15·5°/15·5° C. ...	0·926
Acid value	2·1
Saponification value	196
Iodine value	122

The oil, generally, resembled that from the kernels examined in 1908 (see above). It was of the semi-drying class and consequently unsuitable for the manufacture of either paints or lubricants, whilst its unpleasant after-taste would render its use as an edible oil impossible.

PURGING NUTS.

Lagos.

A small consignment of these oil-seeds was forwarded to the Imperial Institute from Lagos in October, 1903.

The seeds were identified at the Imperial Institute as those of *Jatropha Curcas*. This plant is cultivated in the Portuguese colonies for the sake of its seed which is exported to Lisbon and is there employed for the preparation of curcas oil.

The seeds, on chemical examination, gave the following results. The kernels constituted about 66 per cent. by weight of the whole seeds. On extracting the decorticated seeds with ether, they yielded 52 per cent. of an oil, which had a yellow colour, a faint, peculiar odour, and a bland, nutty taste.

It furnished the following constants; the results of previous observers are added for comparison:—

	Present sample.	Previous observations.
Specific gravity at 15° C.	0·919	0·919-0·925
Free fatty acids—		
Acid value	4·47	—
Free acids (calculated as oleic acid) ... ... per cent.	2·25	0·36–11·8
Saponification value	204·0	192–210
Iodine value	99·1	98–110

This oil can be employed for the manufacture of soap and candles, and also as an illuminant and a lubricant, but is not well adapted for the last-mentioned purpose on account of its semi-drying properties. It is a strong purgative, and in India is used medicinally.

Samples of the seed and the oil were submitted to brokers and experts who reported that the oil can be used for soap-making, but at the present time would not be worth more than £14 to £15 per ton. The cake left after the expression of the oil would be unsuitable as a cattle food owing to its purgative action, and could only be used as a manure, for which purpose it would be worth from £2 to £3 per ton. The value of the seeds, therefore, would not be more than £4 to £5 per ton (May, 1904).

CROTON SEEDS.

Nyasaland.

This sample was forwarded to the Imperial Institute from Zomba in November, 1909. It was labelled "*Croton Tiglium* seeds" and consisted of small, brownish, mottled seeds with the usual characteristic dull surface of croton seeds. The average weight of a single seed was about 0·16 gram. About 8 per cent. of the seeds in the sample had no kernels; the bulk, however, consisted of kernel 64 per cent., and shell 36 per cent.

The kernels yielded 58 per cent. of oil, equivalent to 37 per cent. on the whole seeds.

The oil was of a bright yellow colour, had a faint smell, and possessed the property, characteristic of croton oil, of blistering the skin. It was examined with the following results:—

	Present sample.	Commercial croton oil.
Specific gravity at 15·5/15·5° C. ...	0·939	0·937 to 0·943
Saponification value	203	194·5 to 215
Iodine value	110	101·7 to 109

These results show that the characters of the oil from the present sample of seeds are identical with those of the ordinary croton oil of commerce.

There is a small but regular demand in the United Kingdom for croton seed, the market price of which was quoted at 40*s.* to 50*s.* per cwt (February, 1910).

CROTON ELLIOTIANUS SEEDS.

East Africa Protectorate.

A sample of the seeds of *C. Elliotianus*, Baill., was forwarded to the Imperial Institute from Nairobi in January 1906, for examination in order to determine the value of the oil which they contain.

The sample consisted of decorticated seeds, some of which were found to have turned brown. Only the fresh ones were used in examination.

The seeds were extracted by light petroleum, and yielded 27·7 per cent. of a yellowish oil.

On chemical examination the oil was found to possess the following constants, for comparison with which the corresponding figures for croton oil derived from *Croton Tiglium* have been added.

	Oil of *Croton Elliotianus.*	Oil of *Croton Tiglium.*
Specific gravity at 15° C. ...	0·9236	0·937–0·943
Acid value	4·24	—
Saponification value ...	201·5	194·5–215
Iodine value	138·5	101·7–109
Hehner value	94	88·9–89·1
Titer test	13·7°–13·8° C.	—

These constants show that the oil of *C. Elliotianus* is quite different from ordinary croton oil, the product of *C. Tiglium* (see above), and, unlike the latter, it does not appear to possess vesicating properties.

The oil of *C. Elliotianus* would be less suitable for soap-making than cotton-seed oil, as the melting-point of the fatty acids is low, and it might be difficult to sell when large supplies of cotton-seed oil are available. But under present conditions when vegetable oils are scarce and dear this product could be readily disposed of at a price somewhat lower than that of cotton-seed oil.

The oil has been found by Professor Cash of Aberdeen University to possess purgative properties similar to those of castor oil.

CROTON MACROSTACHYS SEEDS.

UGANDA.

A small sample of the seeds of *Croton macrostachys*, Hochst., was received from Uganda. These were heavy seeds with greyish-brown or black thick shells and white kernels. The whole seeds were found to contain 19 per cent. of an orange-yellow coloured, rather viscous oil of a semi-drying character having a specific gravity of 0·871 at 99/15·5° C. The amount of oil obtained was not sufficient for further examination. The oil was devoid of any vesicating action on the skin such as is possessed by the oil of *Croton Tiglium*.

OMPHALEA MEGACARPA SEEDS.

TRINIDAD.

A small quantity of the seed of *Omphalea megacarpa*, Hemsl. (*O. diandra*), N.O. Euphorbiaceae, forwarded to the Imperial Institute from Trinidad, was examined with the following results:—

The seeds consisted of shell 28 per cent. and kernel 72 per cent. The kernels, when extracted with light petroleum, yielded 65 per cent. of oil, equivalent to 46·8 per cent. in the whole seeds.

The oil was pale yellow, faintly bitter, readily soluble in chloroform or ether, and soluble in 97 per cent. alcohol to the extent of one part in 140 parts at 25° C. It burnt without much smoke or smell, and when exposed to the air in a warm place for several days it only became slightly thicker. The oil was slowly saponified by alkali with the formation of a white soap.

The following constants were determined:—

Specific gravity at $\frac{15 \cdot 5^\circ C.}{15 \cdot 5^\circ C.}$ ...	0·922
Acid value	1·47
Saponification value	190·3
Ester value	188·8
Iodine value	119·7
Melting point of fatty acids ...	36°–37·5° C.
Solidifying point of fatty acids ...	31·5° C.

The oil is less viscous than castor oil and varies greatly in other respects as is evident from the following comparison. In particular, the iodine value of the Omphalea oil is higher than that of castor oil, and indicates the presence of a larger proportion of unsaturated fatty acids.

	Omphalea megacarpa Oil.	Castor Oil.
Specific gravity $\frac{15 \cdot 5^\circ C.}{15 \cdot 5^\circ C.}$ ...	0·922	0·959–0·968
Saponification value ...	190·3	176–186·6
Iodine value	119·7	81·4–90·6

Physiological Action.

Professor Cash, F.R.S., has undertaken a study of the physiological action of *Omphalea megacarpa* seeds and has arrived at the following conclusions:—

The seeds exert a purgative action due to the fixed oil, the degree of action being in direct proportion to the amount of oil present.

The oil probably increases peristalsis by stimulating the intramural nervous plexuses of the intestine. It also produces diuresis owing presumably to a stimulation of the kidney tissues, but the exact mode of action is not yet determined.

The dose of the oil is about four grams. The oily nature of the material, apart from the purgative principle, is considered to add slightly to the purgative effect by exerting a feeble mechanical action.

The oil is regarded as a valuable non-irritant cathartic and its activity does not decrease appreciably with age. The dose required is much smaller than that of castor oil and the taste is not unpleasant.

NON-DRYING OILS.

Typical, commercial non-drying oils are those derived from the olive, almond, peach-kernel and ground-nut. Of the typical products of this class included in this part of the Selected Reports the only well-known material is the ground-nut of which a number of samples from various Colonies have been examined. This oil-seed is very little used in the United Kingdom and the best market for it is Marseilles. Full information regarding the cultivation and uses of the ground-nut is given in the *Bulletin of the Imperial Institute* (1910, **8**, 153). Some of the principal producing countries are India, Senegal and Gambia. The exports from India in 1910-11 amounted to 184,507 tons valued at £2,036,394 whilst those from the Gambia in 1910 amounted to 58,456 tons worth £387,943.

Castor oil which is quite different in type from the other oils included in this class is conveniently discussed along with them because it shares with them the characteristic of not drying on exposure to air.

India is the chief country producing castor seed and castor oil. The total exports of castor seed from India in 1910-11 amounted to 2,148,033 cwt. valued at £1,099,975, and of castor oil to 1,099,967 gallons worth £112,697. For information regarding the cultivation and uses of castor seed the *Bulletin of the Imperial Institute* (1911, **9**, 17) should be consulted.

GROUND-NUTS.

SUDAN.

A supply of ground-nuts was received at the Imperial Institute from the Sudan in June 1906. It consisted of unshelled nuts, free from dirt, but rather small and somewhat shrivelled.

The percentage of oil in the kernels was 51·9, equivalent to 40·1 per cent. from the unshelled nuts. The yield of oil from the kernels was higher than the average figures recorded, which range from 43 to 45 per cent.

The oil was examined chemically and the results obtained indicated that it was quite equal in quality to the ground-nut oil of commerce.

The nuts were submitted to brokers who reported that they were not of sufficiently good quality to be used for edible purposes but that large consignments could be sold to oil-seed crushers. The current value of the kernels for the latter purpose was stated to be £11 to £12 per ton or £8 to £9 for the nuts (November 1906).

NATAL.

These nuts were forwarded for examination to the Imperial Institute by the Commercial Agent for Natal, in December 1908.

The sample was labelled "Elephant Ground-nuts" and consisted of ground-nut kernels which varied from $\frac{1}{2}$ to $\frac{7}{8}$ inch in length and from $\frac{3}{16}$ to $\frac{3}{8}$ inch in thickness. The smaller kernels

were as a rule much shrivelled. There were also present some blackened perished kernels and a few pieces of straw and husk.

A portion of the sample was submitted to commercial experts, who reported that the nuts were of good quality, but somewhat too dry and with a few damaged kernels. They valued the kernels at £14 per ton delivered in Marseilles (March 1909).

GAMBIA.

Two samples of ground-nuts were received.

No. 1. "Ordinary Gambian ground-nut, Tio, Sika." These were somewhat elongated nuts in good condition, consisting of kernel, 66 per cent., and shell (husk) 34 per cent. Most of the nuts contained two kernels each, and about 13 per cent. contained three. The kernels yielded 50 per cent. and the whole nuts 33 per cent. of pale yellow, liquid oil.

No. 2. "Light-skinned ground-nuts, Bantankilling. From 3 or 4 seeds received from Senegal." The nuts in this sample consisted of kernel, 80 per cent., and shell (husk) 20 per cent. They were rounder than the ordinary variety of ground-nut. Most of them contained two kernels each but none were found with three, and about 16 per cent. had only one kernel. A few somewhat mouldy kernels were present in the sample. The kernels had dirty-white or buff-coloured skins. The kernels contained 49·5 per cent. and the whole nuts 39·6 per cent. of pale yellow liquid oil.

The following table shows the results of chemical examination of oil extracted from these two varieties of ground-nuts:—

—	Oil from nuts of sample 1.	Oil from nuts of sample 2.	Commercial ground-nut oil.
Specific gravity at 15·5/15·5°C.	0·928	0·928	0·918–0·925
Saponification value	191	190	185·6–197
Iodine value	89	85	83·3–105

From the results of these examinations it appears that the Bantankilling ground-nuts furnish a larger proportion of kernels than the ordinary Gambia variety and therefore give a somewhat larger percentage of oil calculated on the whole nuts. This difference is, however, probably not sufficient to give the Bantankilling variety any considerable advantage over the ordinary kind from a commercial point of view, unless this variety gives a larger yield of nuts or offers any advantage in cultivation.

A third sample of ground-nuts was forwarded to the Imperial Institute by the Colonial Secretary at Bathurst, Gambia, in January, 1911. It was labelled "Fiji ground-nuts grown at Kotu by Senor Morales." The nuts were large, each containing two kernels. They consisted of kernel 73 per cent. and husk 27 per cent. A sample from Fiji previously examined at the Imperial Institute consisted of kernel 75 per cent. and husk 25 per cent. (see p. 476).

The kernels yielded 48·2 per cent. of oil, whilst those of the sample from Fiji previously examined contained 49·1 per cent. The oil had the usual appearance of ground-nut oil and was not submitted to chemical examination.

The sample was too small for valuation, but ground-nuts of similar quality would, when decorticated, probably realise the normal price of good ground-nut kernels, viz: £14 10*s*. to £15 10*s*. per ton in London (March 1911).

There is a small demand for unshelled ground-nuts of this description, but it is very uncertain, and the price shows considerable fluctuations.

CEYLON.

Samples of ground-nuts and ground-nut kernels were received from Ceylon in June 1904. They were of excellent quality. The kernels as extracted from the nuts were valued at £10 to £10 10*s*. per ton, and the kernels as received from Ceylon were valued at £9 2*s*. 6*d*. per ton (July 1904).

FIJI.

A sample of "Fiji peanuts, Spanish variety," was received in October 1908.

It consisted of large ground-nuts, some containing two kernels and some only one. The nuts containing two kernels varied in length from 1·2 to 1·8 inch, and those containing one kernel from 0·8 to 1·1 inch. The kernels were from 0·6 to 1·0 inch in length, and formed 75 per cent. of the total weight of the nuts. The kernels yielded 49·1 per cent. of oil. This represents a good average yield.

This sample was too small for trustworthy commercial valuation. The nuts were, however, somewhat larger than usual and might possibly be applicable to special edible purposes.

A second sample received from Fiji in July 1909 consisted of unshelled nuts, was labelled "Spanish peanuts," and was described as representing the 1909 crop grown at the experimental station at Lautoka.

The nuts were mostly in very good condition, but a few were slightly damaged or discoloured. They were large, varying in length from 1¼ to 2 inches with an average of about 1⅝ inch. Most of the nuts contained two kernels but there were a few containing only one. The kernels extracted from the nuts were in good condition, very few being shrivelled or discoloured. They were of normal size, colour and appearance, and formed about 70 per cent. by weight of the unshelled nuts.

The sample of Fiji ground-nuts previously examined at the Imperial Institute (see above) was found to give an average yield of oil, and as the present sample was quite similar no further analysis was made.

The best market for ground-nuts is Marseilles, and for that reason samples of these Fiji nuts, previously shelled, were submitted to a firm in that port for valuation. They reported that the kernels would sell in Marseilles at about the same rate as Coromandel kernels, viz., 30 fr. per 100 kilos. (about £12 per ton) in December 1909.

Samples of the shelled nuts were also supplied to brokers in Liverpool, who stated that they would be worth about as much as Chinese kernels, viz., £13 10s. to £14 per ton, c.i.f. (December, 1909).

MONTSERRAT.

Eight samples of undecorticated ground-nuts, grown experimentally in Montserrat, were received for examination in January 1912. The samples were as follows:—

No. 1. "Local."—Rather small nuts, with dirty-looking husks and small kernels with reddish-brown skins. Many of the kernels were shrivelled.

No. 2. "Gambia (3-seeded)."—Fair-sized nuts, which had in most cases clean husks of good colour. The kernels were mostly plump and clean, with pinkish skins; a few however were shrivelled. 22 per cent. of the nuts contained three kernels each.

No. 3. "Gambia."—These nuts resembled the preceding variety, but the kernels were darker, and a larger number were shrivelled; none of them contained more than two kernels.

No. 4. "Spanish."—Small nuts of dirty appearance, with very small rounded kernels which had pale pinkish-brown skins. A good many kernels were shrivelled.

No. 5. "Carolina Running."—Large, rather long nuts, of dirty colour and containing very large kernels, mostly with reddish-brown skins. Some kernels had skins of a dirty brown colour, and a few were shrivelled.

No. 6. "Carolina Running (small seeded)."—Fair-sized nuts of rather dirty colour, with kernels of medium size having skins varying in tint from reddish-brown to dirty brown. A few kernels were shrivelled.

No. 7. "Virginia Running."—Large nuts of good appearance, in most cases having clean-looking husks and somewhat long plump kernels, with rather dark red skins. Some shrivelled kernels were present.

No. 8. "Red Tennessee."—Very long, large nuts, of fairly good appearance, with very dark reddish-brown kernels of fair size; a considerable number of the kernels were shrivelled. Nearly half the nuts contained three kernels. The kernels had a rather unpleasant taste.

The following table shows the average weight of the single nuts in each sample, the percentage of husk and kernel, and the percentages of nuts containing one, two, three, or no kernels:—

Sample No.	1.	2.	3.	4.	5.	6.	7.	8.
Average weight of a single nut in grams.	0·87	1·20	1·14	0·65	1·62	1·36	1·97	1·96
Percentage of husk ...	30	30	33	24	30	26	30	36
Percentage of kernel ...	70	70	67	76	70	74	70	64
Percentage of nuts containing :—								
1 kernel	13	10	16	35	22	17	9	20
2 kernels	83	60	84	61	76	80	91	29
3 kernels	Nil	22	Nil	Nil	Nil	Nil	Nil	49
No kernel ...	4	8	Nil	4	2	3	Nil	2

The nuts were submitted for valuation to (1) a firm of brokers in Liverpool, (2) a large firm of oil-seed crushers in Marseilles, and (3) a firm of merchants in Hamburg. The three firms reported on the samples as follows:—

(1) The samples are all of very inferior colour, and of a quality rarely marketed in Liverpool. They are not fine enough for sale to English fruit merchants or confectioners, and would be more likely to find a market among Continental oil-seed crushers. Their values in Liverpool, ex quay, in bags, would probably be approximately as follows:—

Sample No.	Name.	Price per cwt. s.	d.
1	Local	10	0
2	Gambia (three-seeded)	10	0
3	Gambia	12	0
4	Spanish	9	0
5	Carolina Running	11	0
6	Carolina Running (small seeded)	10	0
7	Virginia Running	12	6
8	Red Tennessee	12	0

(2) These ground-nuts should realise in Marseilles prices similar to those obtained for "Gambia" nuts, the current value of which is 35 fr. per 100 kilos. (14*s*. 2*d*. per cwt.), c.i.f. Marseilles (April, 1912).

(3) The value of the samples for edible purposes, c.i.f. European ports, should be as follows, with Rufisque ground-nuts at 36 fr. per 100 kilos. (14*s*. 7*d*. per cwt.):—

Nos. 1, 2, 3, and 6 about 34 fr. per 100 kilos. (13*s*. 10*d*. per cwt.).

No. 4 about 32 fr. per 100 kilos. (13*s*. per cwt.).

Nos. 5, 7, and 8 about 30 fr. per 100 kilos. (12*s*. 2*d*. per cwt.).

It may be pointed out in connection with these valuations that the current price of undecorticated Coromandel ground-nuts in the United Kingdom at the time of the report was 13*s*. to 14*s*. per cwt. (May, 1912). Rufisque ground-nuts suitable for edible use are more valuable, and good samples are worth about 17*s*. per cwt. (April, 1912).

It is clear from the foregoing results that these ground-nuts would be saleable in Europe. The large supplies of undecorticated ground-nuts imported to the Continent are mainly used for the preparation of edible oil, whilst the small quantities imported to the United Kingdom are used as edible nuts. For the latter purpose it is desirable that the husks should be clean and of good colour, and special attention would have to be given to these points if it is proposed to export ground-nuts from the West Indies to the United Kingdom.

GROUND-NUT OIL.

SOUTHERN RHODESIA.

This sample was a pale yellow oil, which on chemical examination furnished the following constants:—

Specific gravity at 15·5° C.	0·916
Acid value	2·0
Saponification value	188·1
Iodine value	93·0

These results show that the product was of good quality.

The commercial experts reported that the oil was decidedly pleasant, probably superior to the highest grade oil met with in this country, and worth about £40 per ton (October, 1905).

It is evident from the foregoing report that this sample of ground-nut oil was of good quality and value.

North-Eastern Rhodesia.

This was a sample of very pale yellowish oil with a faint not unpleasant odour and taste. It gave the following results on examination:—

Specific gravity at 15·5°/15·5° C. ...	0·919
Acid value	2·2
Saponification value	189·7
Iodine value	96·5

This oil would realise the current price of ground-nut oil, £38 to £45 per ton, London (September, 1911).

This sample had the usual characters of ground-nut oil and was of very good quality; and judging from its low acid value and pale colour, it had been carefully prepared.

The value of ground-nut oil varies, as indicated by the range of prices quoted, depending on its colour and freedom from unpleasant taste and odour. Fresh oil of as good quality as the present sample would probably realise the higher price mentioned above, if it were obtainable regularly in quantity.

Northern Nigeria.

This was a small sample of a cloudy, pale brownish-yellow oil, which became bright and lighter in colour on filtering. The oil had a slight unpleasant odour, suggesting that it had been overheated in preparation. The colour and cloudiness of the sample showed that it had not been carefully prepared. Its constants were as follows:—

	Northern Nigeria oil.	Commercial ground-nut oil.
Specific gravity	0·916	0·918 to 0·925
Acid value	1·2	—
Saponification value ...	187·0	185·6 to 197
Iodine value	83·6	83·3 to 105

The sample possessed the usual characters of ground-nut oil, but on account of its slight peculiar odour and taste it would only be suitable for soap-making.

Mauritius.

A sample of this oil was forwarded from Mauritius in April, 1909.

It was labelled "huile de pistache," and consisted of an imperial quart of pale yellow oil having a bland oleaginous odour and taste. On standing it deposited a minute amount of flocculent white matter.

On chemical examination the oil gave figures which were in close agreement with those of the ground-nut oil of commerce.

It was submitted to commercial experts for valuation. They reported that they considered it to be of extra fine quality and that its value was probably about 30*s.* per cwt. (July, 1909.) They added that ground-nut oil would be practically unsaleable in London, but that it would generally be in good demand at Marseilles.

HONG KONG.

Four samples of ground-nut oil were received.

No. 1.—This oil is said to be imported from the Hoifung district of Kwantung Province, and it is stated large quantities are already being exported to San Francisco.

The oil was pale yellow and slightly cloudy.

No. 2.—This oil is said to be produced at Ping-chau, an island within the Hong Kong New Territories.

The sample consisted of pale yellow, clear, bright oil.

No. 3.—This oil is said to be imported from Shanghai. It was yellowish in colour, rather darker than sample No. 2, and slightly cloudy.

No. 4.—This oil, which is said to be imported from Chinkiang, was pale brownish-yellow and slightly cloudy.

A small quantity of brown sediment was present in all four samples of oil.

The results of examination and commercial valuation of these oils are shown in the following table:—

—	No. 1.	No. 2.	No. 3.	No. 4.
Specific gravity at $\frac{15 \cdot 5^\circ \text{C.}}{15 \cdot 5^\circ \text{C.}}$	0·916	0·919	0·919	0·920
Acid value	9·4	3·2	3·3	7·4
Saponification value ...	190·5	190·5	189·5	189·0
Iodine value	87·7	99·4	99·2	100·1
Value per ton in London, with finest ground-nut oil at £38 to £45 per ton (Feb. 1912).	£30 less 2½ per cent. discount.	£29 less 2½ per cent. discount.		£28 less 2½ per cent. discount.

PENTACLETHRA MACROPHYLLA SEEDS.

SOUTHERN NIGERIA.

This consignment of the seeds of *Pentaclethra macrophylla*, commonly known as the "oil bean" or "owala bean" in Southern Nigeria, and as "fai bean" in Sierra Leone, was forwarded to the Imperial Institute by the High Commissioner for the Protectorate, who desired to obtain definite information regarding the value of these beans as a source of oil.

The consignment weighed about 6 cwt., and consisted of large flattened beans covered with a hard brown testa (seed coat). They were from 1·5 to 2·75 inches in length, 1·2 to 1·8 inches in breadth, and 0·3 to 0·4 inch in thickness. The kernels of the fresh beans should be white and soft, but in the present consignment a comparatively small proportion of the kernels were white, the bulk being brown or black, probably as the result of decomposition.

A quantity of the oil present in the kernels was prepared and its principal constants determined. The residue left after extraction of the oil from the kernels was analysed to ascertain its value as a feeding-stuff.

The results of these investigations are as follows:—

	Per cent.
Proportion of hard seed coat in beans (by weight)	20·7
Proportion of kernel in beans (by weight)	79·3
Amount of oil contained in the whole beans	31·2
Amount of oil contained in the kernels (*i.e.*, the beans freed from the seed coats)	39·0

It has been pointed out already that a large proportion of the kernels had become discoloured, and as this had probably affected the oil contained in them, it was considered advisable to prepare two specimens of oil, one from an average sample of the beans, and the other from a selected sample, consisting of beans with undecomposed kernels. The constants of the two specimens of oil so prepared are given in the following table:—

	Oil from beans with undecomposed kernels.	Oil from an average sample of beans.
Colour of oil	Pale yellow.	Yellowish-brown.
Odour of oil	Slightly pungent.	Pungent.
Specific gravity at 100° C. ...	0·8637	0·8627
Solidifying point	8° C.	5° C.
Saponification value	185	182
Acid value	4·6	10·0
Iodine value	94·3	94·4
Hehner value	94·2	95·7
Unsaponifiable matter... ...	—	0·27
Titer-test	52·4° C.	53·4° C.

It will be seen that the oil from the average sample of beans was darker in colour, more pungent, and possessed a higher acid value (*i.e.* was more rancid) than that prepared from the selected beans. The oil does not "dry" when exposed to the air, even at temperatures slightly above the atmospheric. It possesses an unpleasant pungent odour (even when prepared from undecomposed kernels), which is not removed by any of the simple processes in general use for refining oils. On standing for some time it slowly deposits a quantity of solid fat.

The chemical examination having indicated that this oil might be suitable for the manufacture of soap, a portion of the consign-

ment of beans was submitted to a firm of soap manufacturers, who kindly undertook to extract the oil and make a trial of it as a soap-making material. Considerable difficulty was experienced in preparing the oil for this technical trial; in particular, it was found necessary to decorticate the beans before extracting the oil, in order to avoid inclusion of the brown colouring matter of the hard seed coat.

The firm of soap-makers reported on the oil as follows:—

"The oil obtained from the decorticated seeds was much lighter than that prepared from the undecorticated seeds; it contained comparatively little albuminous matter, but possessed a pungent odour. Its constants were:—

Iodine value	87·07
Acid value	14·3
Titer test	50·15° C.

The oil, despite the high melting point of its fatty acids, yields a rather soft soap. As this soap is inferior in colour, is somewhat softer, and has a far stronger odour than that from cotton-seed oil, we have no hesitation in putting its value at £3 per ton below this oil" (refined cotton-seed oil was at the time of the report worth from £24 to £26 per ton).

Composition of the Meal.—The meal left after the extraction of the oil from the selected beans containing undecomposed kernels was used for analysis. It gave the following results:—

	Per cent.
Moisture	12·9
Ash	3·5*
Proteins	34·8
Fibre	6·6
Sugar (dextrose)	8·2
Carbohydrates (other than sugar) ...	33·7

These figures indicate that this meal possesses a high nutritive value, and compares favourably in this respect with the feeding-cakes prepared from linseed, cotton-seed and other similar materials. No analysis of the meal left after the extraction of the oil from the unselected beans was made because this material was very dark coloured and possessed an unpleasant odour, which would prevent its use as a cattle food. Such material could probably only be used as a manure.

It is impossible to say definitely what the commercial value of cake prepared from the beans with undecomposed kernels would be, since the amount of such material obtainable from this consignment was so small that no cake could be prepared, and no feeding trials with animals could be carried out, and such trials are essential before this residue could be safely suggested for feeding purposes.

In drawing conclusions as to the commercial prospects of the oil beans of *Pentaclethra macrophylla* from the results of the chemical examination and technical trial, it should be borne in mind that, as already indicated, the consignment of beans sent

* Containing 22·6 per cent. of phosphoric acid (calculated as P_2O_5), and equivalent to 0·55 per cent. of phosphoric acid (calculated as P_2O_5) in the meal.

to the Imperial Institute was not in a fresh condition, and that the decomposition which had taken place in the kernels of the bulk of the beans had no doubt to some extent adversely affected the oil, and to this circumstance was no doubt due in part the dark colour and objectionable odour referred to by the firm of soap-makers, and it is possible that if the consignment of beans had been fresh a more favourable view of the technical possibilities of the oil might have been taken. That this is the case is shown by the results of trials of a subsequent consignment from Sierra Leone (see below).

The results of the chemical examination of the oils derived respectively from undecomposed kernels and from an average sample of kernels (see above) show, however, that the chemical nature of the oil has undergone but little change as the result of the decomposition of the kernels. Consequently the softness of the soap produced is probably a constant feature, and therefore the price obtainable for it, even when made from fresh kernels, will no doubt always be less than that paid for cotton-seed oil, which yields a harder soap.

Assuming that it is possible to prepare a feeding-cake from the fresh beans which would to some extent add to their value, beans in good condition would probably be worth from £5 to £5 10*s.* per ton in this country.

It appears that small consignments of these beans have from time to time during recent years been placed on the Antwerp market from the Belgian Congo. They have met with a slow sale, usually at prices equivalent to about £5 per ton, and it is stated that this price has proved unremunerative to exporters, and that the trade has almost if not entirely ceased.

In conclusion, it appears unlikely that there will be in the near future either a large or profitable market for these beans, and though it might be worth while if the beans are available in large quantities to ship them on the chance of securing a small return, especially when as in recent years oil-seeds are fetching abnormally high prices, it would not be advisable to encourage the natives to plant *Pentaclethra macrophylla* for the sake of exporting the beans.

Sierra Leone.

A consignment of the same seeds was received from Sierra Leone in 1909. These were in better condition than the seeds received from Southern Nigeria (see above) and the kernels showed very little discoloration.

As a preliminary examination of these beans had been made already with the small consignment received from Southern Nigeria (see above) it was unnecessary to make a further detailed laboratory examination in this case. The consignment was therefore used almost entirely for a factory trial for the expression of oil. For this purpose it was forwarded to a firm of oil-seed crushers, who pressed over a ton of the beans.

The whole beans contained slightly over 36 per cent. of their weight of oil, and on expression gave the following results:—

First pressing (cold): Yield of oil, 20·2 per cent., calculated on the weight of seeds used.

Second pressing (of cake from first pressing), at 77° C. (170° F.): Yield of oil, 11·17 per cent., calculated on the weight of the cake used.

The total yield of oil by expression was therefore about 30 per cent. by weight of the seeds.

The cold-pressed oil (first pressing) was deep golden-yellow in colour, and on standing deposited a small amount of solid matter. The hot drawn oil (second pressing) was of dull yellow colour, and rather thick consistence. Both oils were free from marked odour, but the hot drawn oil had a faintly bitter after-taste, from which the cold drawn oil was free.

The oil on analysis gave the following results, which are in agreement with those previously recorded for this oil (see above):—

Specific gravity at 15·5° C. (60° F.) ...	0·9194
Saponification value	184·2
Free fatty acids, per cent.	0·7

The press-cake gave the following results on analysis:—

	Per cent.
Oil	12·0
Moisture	9·8
Crude proteins	33·2
Carbohydrates	34·8
Fibre	5·7
Ash	4·5

Both the cold and hot drawn oils would be readily saleable, but as regards the former the firm reported that it could be refined to an almost colourless soap oil, and that it appears to lend itself to the making of a first-class edible oil.

The cake remaining after expression of the oil compares favourably in nutritive value with the meals obtained from cotton-seed and other materials used as sources of feeding-cake for cattle. It was, however, described by the oil-seed crushers as only a low-class feeding article, and probably not worth more than £5 per ton. Before it could be definitely recommended as a cattle food, feeding trials would have to be made.

Regarding the beans as originally received, the oil-seed crushers mentioned that owing to their large size the ordinary machinery for preparing oil-seeds for the expression of oil was unsuitable, and if much of this product were treated, certain adaptations would have to be made. They added, however, that it would be quite possible to dispose of the beans in fair quantities if any large supply were likely to be available, and they estimated the value at £6 per ton delivered in London (August, 1909), if shipped in lots of 50 to 100 tons at a time. It is important that consignments of "fai beans" should be dispatched in good condition, as any considerable proportion of decayed kernels would greatly depreciate their value. It is understood that in spite of the rather low price obtainable for them, small consignments of these beans were being imported into this country (October, 1909), and also to France and Germany, for the manufacture of oil.

"IKPAN" SEEDS.

SOUTHERN NIGERIA.

A sample of "Ikpan" seeds was received at the Imperial Institute from Messrs. Alexander Miller Brother and Co. It was stated that they are very abundant in the Cross River district of Southern Nigeria, where they are cultivated and used for food by the natives.

The seeds could not be definitely identified at Kew, but it was stated that they are probably derived from a plant belonging to the natural order Cucurbitaceæ. It is possible that they may be the seeds of one of the forms of water-melon (*Citrullus vulgaris*) common in West Africa. The constants of the oil agree with this supposition.

The seeds were extracted with light petroleum and yielded from 40 to 41 per cent. of a pale yellow oil, which in cold weather deposits a small amount of solid matter, which does not again pass into solution at ordinary temperatures. On chemical examination the oil proved to be very similar to cotton-seed oil in composition and properties, as the following constants show:—

Specific gravity at 15° C.	0·9184
Acid value	5·5
Saponification value	194·0
Iodine value...	106·0
Hehner value	95·5
Titer test	36·0° C.

Samples of the seeds and oil were forwarded to a commercial firm, who reported that the oil could be used for the same technical purposes as cotton-seed oil, and that its value for soap-making would probably be £1 per ton less than that of cotton-seed oil. It was further stated, however, that the taste of the oil and its behaviour under the influence of heat indicate that it should be specially suitable for edible use, and it was thought that the oil from these "Ikpan" seeds might prove equal for edible purposes to the best ground-nut oil, which varies in value from £30 per ton. In order to form a definite opinion upon this point, at least one ton of the seeds would be necessary to enable the suitability of the oil for edible use to be properly determined.

The cake left after the expression of the oil from the seeds would probably prove to be a valuable cattle food. It is very rich in albuminoids and would, on that account, be suitable for mixing with feeding materials poor in proteins in order to raise the proportion of albuminoids to the required amount. Like all such materials, however, it would require to be tested by feeding trials before being recommended for general use.

In a second sample received from Southern Nigeria the seeds were unshelled, and consisted of 36 per cent. shells or husks and 64 per cent. kernels. The latter yielded 40·6 per cent. of oil, equivalent to 25·4 per cent. on the entire seeds, which is practically identical with the previous result.

The oil was clear and pale yellow in colour, and deposited a small amount of white flocculent matter on standing. It gave the following results on examination:—

Specific gravity at 15° C.	0·922
Acid value	1·4
Saponification value	196·5
Iodine value	107

It seems unlikely that commercial consignments of these seeds could be procured at present in Southern Nigeria for export, since it is stated by the Forest Officer for the Eastern Province that there is a large local demand for them as food at higher prices than they would realise in this country.

SENAT SEED.

SUDAN.

The senat plant occurs as a weed in many parts of the Sudan, and is cultivated on a small scale in Central Gezira, and more generally in the Managil district and the Blue Nile Province. Large quantities of the seed might be exported from the Kordofan Province if the cost of transport could be reduced, whilst a considerable quantity would be available also in the Tokar district of the Red Sea Province. Small quantities of the seed were first exported to Marseilles early in 1910, where it sold at about £12 per ton as a substitute for sesamum seed.

The oil expressed from the seed is well known to the natives, who use it for edible purposes. The seeds are also dried and eaten by the people after being crushed, whilst the leaves and fruit cases have been used as a cattle food.

Several forms of the plant are grown in different parts of the Sudan under the following names: "Hameid," "Fagus," "Ajurr," and Tibish." Botanical specimens of the various forms have been received at the Imperial Institute, and were submitted to the Director of the Royal Gardens, Kew, who stated that they all appeared to be cultivated races of *Cucumis Chate*, L. (*C. Melo* var. *agrestis*, Naud.; *C. arenarius*, Schum. et Thonn.). *C. Chate* is said to be indigenous to Egypt, Nubia, and Abyssinia, and Naudin considers it to be the wild type of the cultivated melon.

Six samples of the seed have been examined at the Imperial Institute, with the results given below.

No. 1.—Senat seed. Oval, flat, cream-coloured, cucurbitaceous seeds, 0·7 cm. long and 0·35 cm. wide.

No. 2.—"Fagus" seed. This sample resembled No. 1, but was yellower and somewhat flatter.

No. 3.—Senat seed known locally in Kordofan Province as "Tibish." These seeds resembled in appearance the preceding samples, but they were of a greyish colour and somewhat less rounded in shape. The sample was in a dirty condition.

No. 4.—Senat seed from the Kadugli district of the Jebels Sub-Province, Kordofan. This sample resembled the preceding sample of "Tibish" seed, but was not so dirty.

No. 5.—"Hameid" seed. Light brown seeds, resembling senat seeds in shape and general appearance, but only about one-half as large.

No. 6.—Senat seed from Bara, Kordofan Province. Cream-coloured, flat seeds, rather larger than any of the previous specimens.

All the samples yielded a pale yellow, liquid oil, free from smell or unpleasant taste. The oils from the various samples of seed were examined with the results given in the following table, to which are added the figures for oils from other cucurbitaceous seeds.

	No. 1.	No. 2.	No. 3	No. 4.	No. 5.	No. 6.	Ikpan seed* from Southern Nigeria.	Melon seed (*Cucumis Melo*).	Watermelon seed (*Citrullus vulgaris*).
Yield ... ... per cent.	36·5	31·0	29·5	31·7	30·2	38·4	25·4	43·8	40·8
Specific gravity at $\frac{15·5°C.}{15·5°C.}$	0·923	—	—	0·928	0·925	—	0·918–0·922	—	—
Acid value	1·0	—	—	·0·7	0·7	—	1·4–5·5	—	—
Saponification value ..	192·0	190·5	189·3	189·2	187·0	—	194–196·5	193·3	189·7
Iodine value	117·0	121·3	117·0	124·0	128·5	—	106–107	101·5	118
Titer test...	30·3° C.	—	—	—	—	—	36° C.	36° C.	32° C.

* *See* p. 485.

In the case of No. 1, the Hehner value was 96·6; the percentage of unsaponifiable matter, 0·7; and the Reichert-Meissl value, nil.

This senat-seed oil is similar to the oils derived from other seeds of Cucurbitaceæ, and on account of its pale colour and freedom from smell and taste would be suitable for edible use.

Utilisation of Senat Husks.

Senat seeds are contained in a melon-like fruit usually about three inches in length. With a view to ascertaining the possibility of utilising the husk of the senat fruit after the removal of the seeds, samples of entire fruits, broken husks, and powdered husks were forwarded from the Sudan.

The powdered husks were examined in order to ascertain their suitability for use as a feeding-stuff. The material was found to have the following percentage composition:—

	Per cent.
Moisture	10·63
Crude proteins	10·75
Consisting of:—	
True proteins	5·43
Other nitrogenous substances	5·32
Fat	2·26
Starch, &c.	38·80
Fibre	20·50
Ash	17·06
Nutrient ratio*	1:4·1
Food units†	71·3

No cyanogenetic glucosides or alkaloids were present.

* *The ratio between the percentage of crude proteins and the sum of the percentages of starch and fat, the latter being first converted into its starch equivalent.*

† *The total obtained by adding the percentage of starch to 2·5 times the sum of the percentages of fat and crude proteins.*

The above results show that these senat husks have only a very low feeding value, and contain much fibre and mineral matter. It is, therefore, evident that they would not form a desirable feeding-stuff for cattle, except possibly as a diluent for richer materials.

In view of the high percentage of mineral matter (ash), it was thought they might be of value for manurial purposes. In order to determine this point an analysis was made of the ash, which was found to have the following percentage composition:—

Lime (CaO)	8·42
Magnesia (MgO)	4·11
Potash (K_2O)	42·69
Soda (Na_2O)	0·70
Phosphoric acid (P_2O_5)	2·51
Chlorine (Cl)	2·08
Sulphuric acid (SO_3)	3·85

These figures indicate that the mineral constituents of senat husks should be of value as a manure, particularly for crops requiring potash. It is probable therefore that good results could be obtained by applying the husks direct to the soil as a manure.

BEN SEEDS AND OIL.

These seeds are derived from *Moringa pterygosperma* or *Moringa aptera*, species indigenous to the East Indies, but now widely grown in the Tropics.

NORTHERN NIGERIA.

No. 1. A sample of pods and seeds from the Borgu province was examined. The seed-kernels contained 38 per cent. of oil of pale yellow colour and pleasant taste. The oil was separated into portions respectively liquid and solid at 17° C. (For analysis of oil see table on p. 489).

No. 2. A further supply of about 50 lb. of seed-kernels was received from Northern Nigeria in 1906. These were somewhat mouldy on arrival owing to the fact that they had not been thoroughly dried before packing. To prevent fermentation they were dried by hot air and the greater portion of the sample was sent to a firm of oil manufacturers who obtained 21·14 per cent. of "cold pressed oil," and, on further expression at 60° C., an additional 6·6 per cent. of "hot pressed oil"—a total yield of 27·74 per cent. In both cases ("hot" and "cold" pressed) the oil was of dark colour and contained a high percentage of free fatty acids probably owing to the mouldy state of the seed.

No. 3. This consisted of 107 lb. of seeds. These were expressed hot at a pressure of 45 cwt. per square inch and yielded 14·1 per cent. of yellowish-white oil, which was semi-solid at ordinary temperatures and had a peculiar unpleasant odour. An analysis of the oil is given in the following table.

	No. 1.		No. 2.		No. 3.
	Extracted oil.*		From decorticated seed.		From undecorticated seed.
	Liquid.	Solid.	Cold pressed.	Hot pressed.	Hot pressed.
Specific gravity at 15/15° C. ...	0·914	—	0·902	0·898†	0·913
Acid value	15·3	—	49·7	100·5	2·3
Saponification value	189·2	194·4	179·2	178·7	186·0
Iodine value	70·7	68·3	100·3	88·0	67·7
Unsaponifiable matter ...	—	—	1·67	2·69	—

* *Oil separated on standing at* 17° C. *into liquid and solid portions, which were examined separately.*
† *Specific gravity at* 100/15° C.

Composition of Cake.

The residual cakes left after expression of the oil from the samples 2 and 3 had the following composition. The composition of cotton-seed cake is added for comparison:—

—	Ben seed from Northern Nigeria.		Cotton-seed cake.*	
	Decorticated No. 2.	Undecorticated No. 3.	Decorticated.	Undecorticated.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	5·96	7·5	9·00	13·75
Albuminoids	24·12	30·8	43·78	24·62
Other nitrogenous substances	34·81			
Fat	11·27	14·5	11·38	6·56
Fibre	4·32	21·9	5·18	21·19
Ash	5·66	4·5	7·10	4·60
Other non-nitrogenous substances.	13·86	20·9	23·56	29·28

* *According to Smetham (Ann. Jour. Roy. Lanc. Agric. Soc.,* 1909).

The above analyses show that the undecorticated cake is fairl; rich in nutritive constituents. Owing to the difficulty of re moving the husk or shell from the seed it is probable that onl; undecorticated cake would be manufactured if Moringa seed wer used commercially as a source of oil.

The cake, however, contains an alkaloid (the quantity is smal and its exact nature is not yet known) and also a large quantity c non-albuminoid nitrogenous matter; it is also bitter to the tast so that it is doubtful whether it could be employed as a feedin stuff. The only other use to which the cake could be put woul be to employ it as a manure, its constituents of value for th purpose being as follows:—

		Per cent.
Lime (CaO)	... ...	0·403
Potash (K_2O)	... ...	0·803
Phosphoric acid (P_2O_5)	... ...	1·089
Nitrogen (N)	... ...	4·960

Commercial Valuation.

The oil obtained from sample 3 was examined by a firm of soap manufacturers, who reported that it would be suitable for soap-making and that its value for this purpose would be slightly less than that of cotton-seed oil. They expressed a wish to obtain a few barrels of the oil for trial.

The seed and oil were also submitted to oil-seed crushers, who stated that they might be able to use the seed and expressed a desire to obtain a few tons for practical trial.

Until further trials have been carried out, it is impossible to state definitely the commercial value of Moringa seed. If the residual cake can be used as a feeding-stuff, the value of the seed in the United Kingdom would be about £7 or £8 per ton (May, 1910) according to the price offered for the oil, which would fluctuate in sympathy with that of other soap-making materials. If, however, the cake can only be used as manure, the value of the seed will be less.

It has been frequently stated (see *Bulletin of the Imperial Institute*, 1904, **2**, 117) that Moringa oil is especially suitable as a lubricant for watches and other delicate machinery. A sample of the oil was therefore submitted to a chronometer-maker for practical tests. After trials extending over 18 months, it was found that the oil is not suitable for clocks, as it gets thick and sticky after a time and changes in colour to a dark brown. It corrodes so much that it is believed it could not be used even in very large clocks.

East Africa Protectorate.

The sample of Ben seeds which is the subject of this report was received at the Imperial Institute in October, 1911.

The sample weighed 40 lb. and consisted of the seeds of *Moringa pterygosperma* (Ben seeds), resembling the seeds of this species from Nigeria previously examined at the Imperial Institute. In about 22 per cent. of the seeds, the kernels were either absent or decayed.

The sound kernels yielded 39·2 per cent. of a yellowish oil, against 35 to 38 per cent. in the case of previous samples. The oil deposited some solid fat on standing and resembled in this respect the oil extracted at the Imperial Institute from Nigerian Ben seeds.

BALANITES ÆGYPTIACA.

Fruits, kernels and oil derived from this plant have been received from Northern Nigeria, the Sudan, and Uganda.

Northern Nigeria.

Oil.—This was labelled "Betu oil" from seeds of *Balanites ægyptiaca*. It was cloudy, of bright yellow colour, and possessed a somewhat unpleasant smell. A quantity of dirty greenish-brown sediment was present at the bottom of the bottle containing the oil. After filtration the oil was quite clear, but a white flocculent substance was deposited on standing.

Kernels.—These were about ½ inch long, pointed at one end, and about ¼ inch thick; they were light brown, semi-transparent, rather hard, and had a rancid bitter taste. The kernels yielded 58·7 per cent. of oil.

Sudan.

This sample consisted of the fruits, called in the Sudan "Heglig seeds." They were oval in shape, and had a thin, wax-like outer skin, covering a layer of half-dried, sticky pulp of unpleasant odour; inside this was a hard, thick, fibrous shell, containing the pale yellow, oil-yielding kernel. The yield of oil was 41 per cent. on the weight of kernels, equivalent to 3·6 per cent. on the whole fruit. The oil as extracted from the kernels by solvents was pale yellow and transparent, possessed no marked odour or taste, and showed no tendency to dry after being exposed to the air on a glass plate for several days.

Examination of Oil.

	Balanites oil from Northern Nigeria.	Balanites oil extracted from the Sudan fruits.
Specific gravity	0·919	0·9187
Acid value	5·0	1·4
Saponification value	196·7	194·2
Iodine value	92·5	98·2
Hehner value	95·2	98·6
Reichert-Meissl value ...	—	trace
Unsaponifiable matter ...	0·6 (approx.)	—
Titer test	34·6° C. (approx.)	34° C.
Percentage of oil in kernels ...	58·7	41

The oil is a mixture having roughly the following composition:—olein, 33 per cent.; linolein, 33 per cent.; stearin and palmitin, together 34 per cent.

Uganda.

A sample of oil was received early in 1907 with the information that it was considered by the natives in certain parts of the Protectorate a specific for sleeping sickness, and that it was used in some parts of the Sudan as a purgative. It was asked that experiments might be conducted with the oil, in order to ascertain whether it had any therapeutic value. Prof. Cushny, F.R.S., kindly undertook to make these trials with (*a*) oil extracted from the kernels at the Imperial Institute, and (*b*) oil as prepared in the Nile Province of Uganda. Prof. Cushny's results show that the oil is of no value in the treatment of sleeping sickness, and

that although the native-prepared oil, which was dark-coloured and dirty, exerted an aperient action, this was very slight and not likely to render it of any value in European medicine.

Commercial Value of the Oil and Kernels.

The results of the examination show that the oil of *Balanites ægyptica* closely resembles cotton-seed oil in chemical characters and, like the latter, it could no doubt be utilised in soap-making. Its colour and taste would prevent its use for edible purposes.

Samples of the kernels have been submitted for commercial trial and valuation to a firm of soap-makers, who report that the oil would be worth about as much as refined cotton-seed oil.

It is difficult to give even an approximate valuation for the kernels, since much depends on whether the "cake" left after the expression of the oil is suitable for use as a feeding material.

It is a question for local decision whether it would pay to extract the kernels, which alone are of commercial value, from the fruits for export, as the removal of the pulp and fibrous shell is likely to be a troublesome process.

BALANITES MAUGHAMII FRUITS AND OIL.

PORTUGUESE EAST AFRICA.

Statements have been made recently that a species of Balanites has been discovered growing plentifully in the Lebombo Mountains and on the banks of the Umbeluzi River in Portuguese East Africa, which produces large quantities of fruit, containing kernels rich in oil of high quality and suitable for use as an edible oil.

The fruits of *Balanites ægyptiaca* from Uganda, Northern Nigeria and the Sudan have already been examined at the Imperial Institute (see above), and shown to be incapable, under existing conditions, of systematic exploitation for oil, owing to the difficulty, first, of removing the external sugary pulp, and then of extracting the kernel from the thick fibrous shell which occurs under the pulp.

In view of these facts it seemed unlikely that the fruits of this new species from Portuguese East Africa could be of economic value for export, and this opinion has been confirmed by the examination of specimens of the fruit and oil forwarded to the Imperial Institute by H. M. Consul at Lourenço Marques in October, 1911.

The fruit consisted of an outer sugary pulp enclosing a nut with a very hard, tough, fibrous shell; the kernel of the nut was cream-coloured, oily, and about 1 in. long and ½ in. in diameter.

The fruits were identified at Kew as belonging to an undescribed species of Balanites, since named *B. Maughamii*, Sprague. They resembled the fruits of *B. ægyptiaca*, previously examined at the Imperial Institute, but were larger.

The sample was too small to enable the percentage of oil in the kernels to be determined.

The specimen of oil was clear, yellow, and liquid, possessing no marked smell or taste. The constants of the oil are given in

the following table, compared with the corresponding figures for the oil of *B. ægyptiaca* previously examined at the Imperial Institute.

	Present sample.	Oil from kernels of *B. ægyptiaca*.	
		From Nigeria.	From the Sudan.
Specific gravity at $\frac{15^\circ \text{C.}}{15^\circ \text{C.}}$	0·916	0·919	0·9187
Saponification value	198·5	196·7	194·2
Iodine value	100	92·5	98·2

This oil of *B. Maughamii* from Portuguese East Africa resembles that of *B. ægyptiaca* in appearance and general character, and if produced on a commercial scale it would probably realise about the current price of refined cotton-seed oil. The difficulty and expense of removing the sugary pulp from the fruit, cracking the shells, and removing the kernels would prevent the exploitation of the product on a large scale.

Since this report was forwarded to His Majesty's Consul at Lourenço Marques, experiments with the fruits have also been made in Germany, and the results confirm those recorded above.

CALOPHYLLUM SP. OIL.

INDIA.

This sample of oil was received in July, 1906. It was forwarded as the product of *C. tomentosum*, but the Officiating Reporter on Economic Products has since stated that it was very probably the oil of *C. Wightianum*.

The oil was of a dark greenish-brown colour, viscid, and possessed a slight unpleasant odour; it contained a quantity of solid matter which dissolved on warming, but separated out on cooling. The oil did not dry when exposed to air in thin layers. It yielded the following results on examination to which are added for comparison those furnished by cotton-seed oil:—

	Oil of *Calophyllum* sp.	Cotton-seed oil.
Specific gravity ...	0·9401 at 17° C.	0·922 to 0·930 at 15° C.
Acid value	27·0	(usually almost free from fatty acids.)
Saponification value	199·2	191 to 196·5
Iodine value ...	79·75	100·9 to 116·9
Titer test	31° C.	28·1° to 39·2° C.

The oil contains a considerable amount of coagulable albuminous material, the presence of which would interfere with its use in soap manufacture. It is very dark coloured, gives a dark soap, and is not bleached satisfactorily by any of the ordinary

agents which could be used economically. In view of the high percentage of free fatty acids which it contains it is obviously impossible to use alkali for bleaching it. In the condition of the present sample the oil could only be used for soaps of low quality, but, after being hydrolysed and the fatty acids distilled, products are obtained which are suitable for soaps of higher grade.

The defective condition of the oil is possibly due to the use of an unsuitable process for extracting it, perhaps involving the over-heating of the seeds.

The oil would probably be worth about £1 per ton less than cotton-seed oil.

CALOPHYLLUM WIGHTIANUM SEEDS.

INDIA.

This sample was received at the Imperial Institute in May, 1910.

It was labelled "*Calophyllum Wightianum* seed from District Forest Officer, South Canara, Bangalore, Madras, Regd. No. 32423," and consisted of a mixture of fruits and seeds. The fruits were small and ovoid, with brownish, dry, shrunken pericarp. The seeds had brown, brittle husks and yellowish-white, oily kernels. The kernels formed about 60 per cent. by weight of the sample as received, and contained 72·5 per cent. of bright yellow, liquid oil which furnished the following figures on examination:—

—	Oil of *Calophyllum Wightianum.*	Oil of *Calophyllum* sp. from India previously examined.	*Calophyllum Inophyllum* oil examined by: Fendler.	Lofeuvre.
Specific gravity 15·5°/15·5° C.	0·938	0·940	0·934	0·944
Acid value	13·0	27·0	not recorded.	
Saponification value ...	200·3	199·2	196·0	not recorded
Iodine value	103·0	79·75	92·8	96·0
Titer test	19·6° C.	31° C.	33° C.	33° C.

The amount of unsaponifiable matter in the oil was 1·6 per cent.; Fendler has recorded 0·25 per cent. for the oil of *C. Inophyllum.*

The oil extracted at the Imperial Institute from these seeds of *C. Wightianum* differs somewhat from the oil previously forwarded from India in having a higher iodine value and a lower titer test. It would not be suitable for use as a lubricant, but could be utilised for soap-making. From the results of the chemical examination, the oil of *C. Wightianum* appears to be somewhat similar to the oil of *C. Inophyllum*, which Fendler found to contain palmitin, stearin, and olein. The titer test of the *C. Wightianum* oil is, however, much lower. The oil of *C. Inophyllum* has been stated to possess poisonous properties, and it is therefore doubtful whether the oil of *C. Wightianum* would be suitable for edible purposes.

The seeds of *C. Wightianum* have an unpleasantly bitter taste, and on account of this and the possibility of the presence of poisonous constituents it appears very unlikely that the "cake" obtained on expressing the oil would be suitable for use as a feeding-stuff. The bitter principle seems however to be entirely removed with the oil when the latter is extracted by light petroleum, so that the residual oil-free meal does not possess a bitter taste. The oil can be freed from the bitter principle by shaking it with a solution of sodium carbonate.

As stated in the previous report, the commercial value of this oil would probably be a little below the current market price of cotton-seed oil.

STERCULIA FŒTIDA FRUITS.

Ceylon.

These were received from Ceylon in January, 1912. The sample was composed of fruits measuring about 1 inch in length and ½ inch in diameter, consisting of (1) a dark grey, thin papery outer skin (epicarp), enclosing (2) a thin layer of pale brown pulp (mesocarp), surrounding (3) a seed with a very tough, shiny, dark brown shell and a soft, creamy white kernel. The fruits consisted of epicarp 2·5 per cent., mesocarp 16 per cent., shell 33 per cent: and kernel 48·5 per cent.

The kernels yielded 52·1 per cent. of oil, equivalent to 30·8 per cent. expressed on the seeds or 25·3 per cent. expressed on the whole fruits.

The oil was pale brownish-yellow, and had a faint, not unpleasant smell, and no distinctive taste.

	Present sample.	Figures recorded by Bontoux.
Specific gravity at 15·5°/15·5° C.	0·929	—
Saponification value...	192·5	173·4 to 174·3
Iodine value	87·0	81·4 to 83·1

These fruits are stated to be eaten in Ceylon, but it is improbable that they would find a market in Europe as an edible product, since the kernels, which cannot be removed from the shells without considerable difficulty, do not show any superiority over those of numerous other edible nuts which are already imported into Europe in large quantities.

The oil yielded by the kernels is a light coloured, non-drying oil, which might find a market for soap-making or possibly even as an edible oil. It possesses the somewhat unusual property of being suddenly converted into a gelatinous solid when heated to a high temperature, and for this reason is of considerable scientific interest.

CALODENDRON CAPENSE OIL.

East Africa Protectorate.

A specimen of this oil was received at the Imperial Institute from British East Africa in 1904. The tree yielding the seed occurs rather sparsely in East Africa, and is sometimes grown

there and in South Africa as an ornamental plant. It does not occur, so far as is known, in sufficient quantity to be a commercial source of oil, so that it is merely a matter of general interest to record the characters of the oil. The latter is pale yellow in colour with a slight rather pleasant odour and a somewhat bitter taste. It deposits a small amount of solid matter on standing. On examination it gave the following constants:—

Specific gravity	0·9190
Acid value	27·0
Saponification value	192·0
Iodine value	98·4
Unsaponifiable matter	2·1
Titer test	35° C.

These results indicate that the oil is of a non-drying type and would be suitable for soap-making, but, as there is at present no prospect of it being obtained in quantity, its commercial value need not be discussed.

BAOBAB SEEDS (*Adansonia digitata*).

East Africa Protectorate.

These were received in February, 1911. The sample consisted of brown, kidney-shaped seeds, measuring about ½ inch by ⅜ inch, with hard, thick, tough husks, and soft, white kernels.

The entire seeds yielded 11·6 per cent. of oil. The following yields of oil from the seeds of species of Adansonia have been recorded:—

A. digitata (Senegal)	12·5
A. Za (Madagascar)	16·4
A. madagascariensis (Madagascar) ...	34·4
A. Grandidieri (Madagascar)	42·6

The oil was viscous, clear, and bright yellow, with no marked taste or odour.

It had the following characters:—

Specific gravity at 15·5°/15·5° C. ...	0·920
Acid value	6·2
Saponification value	193·5
Iodine value	82·0

The results of this investigation show that these East African baobab seeds derived from *Adansonia digitata* contain very much less oil than the baobab seeds exported from Madagascar, which are probably derived from *A. madagascariensis* or *A. Grandidieri*. The small percentage of oil present in the East African seeds would render them of no value in Europe as a source of oil.

Baobab seeds from Madagascar containing about 40 per cent. of oil have been valued at about £7 per ton in Marseilles.

TELFAIRIA PEDATA SEEDS.

From time to time enquiries are received at the Imperial Institute regarding the utilisation of Telfairia seeds, the kernels of which are rich in oil, and are stated to be available in quantity in various parts of East Africa. The following is a summary of the information available on the subject.

The plant *T. pedata* is a perennial climber, belonging to the natural order Cucurbitaceæ. It is indigenous to Eastern Africa, Zanzibar, and Pemba.

The kernels of the seeds are stated to be used by natives in tropical Africa both as a foodstuff and as a source of edible oil, and from time to time the suggestion has been made that the seeds might be exploited commercially in Europe as an oil-seed.

The following analysis of the seeds has been published by Gilbert (see Sadebeck, *Die Kulturgewächse der deutschen Kolonien und ihre Erzeugnisse*, Jena, 1899, p. 245):

	Per cent.
Moisture	6·56
Ash	2·04
Oil	36·02
Protein	19·63
Woody fibre	7·30
Nitrogen-free extractive matter ...	28·45

A sample of the seeds from Zanzibar was recently received for examination at the Imperial Institute. They were flat, irregularly circular in shape, and about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. The single seeds averaged 4·9 grams in weight.

The seeds consisted approximately of fibrous husk 11 per cent., shell 38 per cent., and kernel 51 per cent. A previous investigator has recorded 7, 33, and 60 per cent. of fibrous husk, shell, and kernel respectively. The kernels yielded 56·9 per cent. of viscous, slightly reddish-brown oil. Previous observers have recorded yields of 60 to 64 per cent.

The oil extracted from the kernels was examined with the following results:

	Present sample from Zanzibar.	Figures previously recorded by various observers.
Specific gravity at $\frac{15°\,C.}{15°\,C.}$ ...	0·919	0·915 to 0·9185
Acid value	2·6	0·34 ,, 2·44
Saponification value ...	196	186·5 ,, 202
Iodine value	89	84·2 ,, 100·7

The fatty acids of the oil are stated to include stearic, palmitic, and telfairic acids, and an unidentified hydroxy-acid of the formula $C_{24}H_{40}O_3$.

The expressed oil belongs to the class of non-drying oils, and possesses a pleasant, slightly sweet taste. It would be suitable for soap manufacture, but the possibility of preparing an edible oil from this source seems to depend on the discovery of a cheap and efficient method of husking the seeds, since the husks contain an intensely bitter substance. The oil-cake remaining

after pressing the oil from the kernels could probably be used as a cattle food. The cake left after pressing the unhusked seeds would, however, be unsuitable for this purpose, owing to the bitter constituent present in the husks.

The removal of the husk presents considerable difficulty owing to its tough and fibrous nature, and the process of shelling by hand is long and laborious. A German syndicate of soap- and candle-makers at Mannheim is stated to have investigated the commercial possibilities of these seeds, and to have expressed the opinion that until a machine has been invented for rapidly and cheaply decorticating them it would be inadvisable to place consignments on the European market.

The statement has been made that consignments of these seeds have been sold from time to time in Continental markets, and for that reason enquiries have been made by the Imperial Institute in this country, at Marseilles, and at Hamburg, as to whether there is now any import trade in the seeds. The results of these enquiries show that the seeds do not come on the English market, but they have been offered at Marseilles, although never in commercial quantities. The price asked at Marseilles for the unshelled seeds was 30 francs per 100 kilos. (= about £12 per ton), but no business resulted; whilst the husked seeds (kernels) were also offered there some years ago without success. None of the firms with whom the Imperial Institute has been in communication had any knowledge of a machine suitable for the purpose of decorticating the seeds.

It appears that samples of the seeds of *T. pedata*, and also of *T. occidentalis* from West Africa, are received from time to time at Hamburg, but the seeds are not imported there in commercial quantities. No market quotation for the seeds is available at Hamburg, and no machine satisfactory for the decortication of the seeds is known there.

The position with regard to these seeds may be summed up as follows. They are known to yield a fair quantity of oil which could be used commercially. There is a difficulty in making use of them in this way, owing to the fact that the husks contain an intensely bitter substance, which (1) prevents the use of the oil obtained from them for edible purposes, and (2) renders the press cake unsuitable for feeding purposes. This difficulty could be met, as it is in other cases, by shelling the seeds, but unfortunately there is at present no machine available for this purpose, and shelling by hand, even with native labour, appears to be expensive. In spite of these difficulties small consignments of the seeds have been offered from time to time in Europe, but there is no evidence that these have amounted to more than experimental shipments, and it is clear that there is no regular market for the seeds.

In the event of the above-mentioned difficulties being overcome, it should be observed that oil-seed crushers are generally unwilling to take up a new oil-seed unless it is obtainable regularly in large quantities, and so far as can be ascertained at present no large regular supply of Telfairia seeds could be guaranteed even if it were found possible to use them.

CASTILLOA ELASTICA SEEDS.

TRINIDAD.

This sample of the crushed seed of *Castilloa elastica* was forwarded to the Imperial Institute by the Superintendent of the Botanical Department, Trinidad, in July, 1903. It consisted of about 1 lb. of the coarsely ground seed and was of a light brown colour. With it was also supplied a small specimen of the extracted fat which was semi-solid and of yellow colour. Three samples of the fat were submitted to chemical examination. Of these, A was obtained by extracting the seeds with light petroleum for two days in a Soxhlet apparatus, B was obtained by extracting with light petroleum for two hours, whilst C, the specimen referred to above, had been extracted in Trinidad by triturating the crushed seed with carbon disulphide. Since the last-mentioned specimen still retained a small quantity of the solvent, it was heated at 100° in a vacuum before examination in order to remove the last traces of the solvent. On complete extraction with light petroleum the seed yielded 12·5 per cent. of the fat (A) as a pale brown solid which showed a tendency to crystallise owing to the large proportion of free fatty acids present.

The chemical constants of the fat are given in the following table:—

—	A. Extracted with light petroleum.	B. Extracted with light petroleum	C. Extracted with carbon disulphide.
Melting point	Soft at 32° C. and melted completely to a clear liquid at 42° C.	—	Semi-solid at ordinary temperature. Melted to a clear liquid at 38°C.
Solidifying point	Turbid at 40°C. Solid at 30·5°C.	—	Turbid at 37°C. Semi-solid at ordinary temperature.
Free fatty acids :—			
1. Acid value	99·8	96·5	28·2
2 Calculated as oleic acid *per cent.*...	50·2	48·5	14·2
Saponification value	184·4	190·4	196·6
Iodine value	87·9	88·5	90·7
Unsaponifiable matter (resinous substance)	6	—	0·8
Remarks	Seeds completely extracted (2 days).	Seeds only partially extracted (2 hours).	Seeds partially extracted by trituration.

On saponification, the fat yielded a moderately hard soap. The insoluble fatty acids are comparatively hard; when heated they begin to melt at 42·5° C., are completely fused at 47° C. and, on cooling, solidify at 41·5° C. By repeatedly re-crystallising

these insoluble fatty acids from alcohol, palmitic acid was isolated and was identified by the following constants. Melting point, 61° C., acid value, 217·5, iodine value, 0. (The melting point of pure palmitic acid is 62° C., and its acid value 218·7.)

The differences observed in appearance and properties between the specimen of fat C (supplied from Trinidad) and the specimen A are probably due to two causes. In the first place, specimen C was obtained by only partial extraction of the seeds and therefore represents the more liquid portions of the fat, whilst A, having been prepared by complete extraction, contains the whole of the fat, both liquid and solid, together with a certain amount of unsaponifiable, resinous matter. In the second place, whilst both specimens contain a somewhat large proportion of free fatty acids, the quantity in specimen A is much larger than that in specimen C, and it is probable that the presence of these free acids may be due to decomposition of the oil by exposure of the seed in a crushed state to the air for some time before extraction.

A chemical investigation of the fat has shown that it possesses the following approximate composition:

	Per cent.
Oleic acid (free and combined)	46
Palmitic acid (free and combined)...	31
Stearic acid (free and combined)	6
Acids of the linoleic and linolenic series (free and combined)	13

A bitter principle was isolated from the crushed seed by extraction with alcohol, the fat having been previously removed by means of light petroleum. By subsequent treatment of the alcoholic extract, an intensely bitter substance was obtained which crystallises from methyl alcohol in the form of colourless prisms, melts at about 170° C., and is insoluble in light petroleum and in water. This substance contains no nitrogen, and possesses neither acid nor basic properties.

It is doubtful whether the seeds could be commercially utilised with profit, since they furnish only 12·5 per cent. of the oil whilst the crushed seed could not be used as a cattle food on account of its intensely bitter taste.

INOY KERNELS AND OIL.

WEST AFRICA.

Small samples of "Inoy" kernels and nuts from West Africa were received at the Imperial Institute from Messrs. Alexander Miller Brother and Co. of Liverpool, in June 1905, and, as the results of the preliminary examination appeared to be promising, a larger quantity of kernels was obtained from the same source for further investigation. The nuts were identified at Kew as the seeds of *Poga oleosa*.

The nuts were dark brown with a thick rough hard shell and contained small ovoid kernels, covered with a brownish-black, thin husk. The kernels were soft and white internally, and very oily.

A few of the kernels were bad and had become brown internally. These were not used in the examination.

The oil was extracted from the kernels by means of light petroleum, and its examination gave the following results.

The oil was pale yellow in colour, with a rather unpleasant, oleaginous taste and a peculiar odour. It did not become solid on keeping and solid matter was only deposited after standing for several months.

The kernels contained 60·8 per cent. of oil, which had the following constants:—

Specific gravity at 15° C.	0·896
Saponification value	184·49
Iodine value	89·75
Hehner value	93·00
Reichert-Meissl value	1·45
Acid value	39·7
Titer test	22° C.

The following table shows the composition of the dry residual meal after extraction of the oil. No determinations of moisture in the meal were made as most of the water was taken out by the dry light petroleum used in extracting the oil from the ground kernels.

	Expressed on dry material. Per cent.
Proteins	41·51
Sugars, reducing	1·32
,, non-reducing (sucrose)	2·50
Other carbohydrates	36·92
Crude fibre	9·00
Ash	8·75

The ash contained 49·1 per cent. of phosphoric acid (expressed as P_2O_5) in the form of phosphates.

The oil resembles, on the whole, cotton-seed oil, but has a lower "titer" number.

It could probably be used as a substitute for ground-nut, olive or sesamum oils for edible purposes but, in order to determine the suitability of the oil for edible purposes, it would be necessary to have a consignment of a few hundredweights of the kernels so that the oil could be expressed on a commercial scale, and specially examined from this point of view.

The figures given above for the dry, oil-free material, show that the "Inoy" kernels may be expected to yield a nutritious cake suitable for feeding cattle, but further examination is needed to prove its suitability for this purpose. The thin husk on the kernels is not so hard as that on cotton-seed, which is left in the cake, and it is unlikely that there would be any objection to a similar course in the case of the "Inoy" kernels. The thin husk surrounding the kernel should not be confused with the thick hard shell of the "Inoy" nut itself, which would have to be removed previous to export. The difficulty of removing the shells would probably prevent the exportation of the kernels in commercial quantities. At the time of the report the kernels were valued, as an unknown oil-seed, at the nominal price of £9 to £10 per ton in this country (May 1906).

Further samples of "Inoy" kernels, and of the oil prepared by natives in Southern Nigeria, were examined in 1907.

Analyses of the kernels and oil have also been made in this country by Edie and, in Germany by Brieger and Krause. The latter authors obtained their material from Kamerun, where the tree is known as "Njore-Njole" (*Tropenpflanzer*, 1908, **12**, 83). It is of interest therefore to bring these various results together, since they serve to show the extent to which the oil content of the kernels and the usual "constants" of the oil vary.

	Analyses made at the Imperial Institute.			*Analysis made by Edie.*	*Analysis made by Brieger and Krause.*
	Oil extracted from kernels.		Native prepared oil.		
	No. 1.	No. 2.			
Specific gravity at 15°/15°C.	0·896	0·914	0·918	0·9091*	0·9135†
Acid value	39·7	45·3	—	56·0	—
Saponification value ...	184·49	192·9	184·05	188·0	193·05
Iodine value	89·7	90·9	85·35	93·0	93·3
Hehner value	93·0	94·5	—	—	—
Reichert-Meissl value ...	1·45	nil.	—	—	0·66
Titer test...	22°C.	24·5°C.	—	—	—
Percentage of oil from kernels	60·8	—	—	57·4	62

* Determined at 20° C. and compared with water at 4° C.

† Temperature not stated.

OIL-SEED FROM SOUTHERN NIGERIA.

Small samples of an unknown oil-seed from Southern Nigeria, and of oil extracted from the seed by natives, were forwarded to the Imperial Institute by a firm of Liverpool merchants with a request for information as to the identity of the seed and of the probable value of the oil and seed. The seeds were forwarded to the Royal Botanic Gardens, Kew, and were there identified as being of the Nat. Ord. Sapindaceae. Further identification was impossible until plants had been propagated from the seeds.

The seeds were about the size of hazel nuts and had a thin reddish-brown soft shell and a lighter-coloured inner skin. The interior was composed of white semi-transparent tissue very rich in oil.

The oil was almost colourless and transparent and had a slightly rancid smell and a bland oleaginous taste; it contained a small quantity of solid "stearin" and yielded the following results upon examination:—

Specific gravity at 15°/15° C.	0·916
Acid value	3·5
Saponification value	186·3
Iodine value	80·7
Hehner value	95·4
Reickert-Meissl value	1·3
Titer test	31·1° C.

As the oil is a non-drying one and free from smell, taste or colour, it would probably be of value as an edible oil, or would yield a good white soap. Attempts are being made to obtain further supplies and information regarding this oil-seed.

TEA-SEED OIL AND TEA-SEED CAKE.

Hong Kong.

These materials are obtained from the seeds of *Camellia Sasanqua*, a near relative of the tea-plant, *C. Thea*. *C. Sasanqua* is grown by the Chinese mainly for the sake of its seeds, from which the oil is expressed and used as an illuminant. The cake left after expressing the oil is used as a substitute for soap. The possibility of using it in this way is no doubt due to the large amount of saponin in the cake (see below).

The oil and cake now reported on were received from Hong Kong.

Oil.—This was a yellowish-brown, slightly opalescent oil, said to be imported to Hong Kong from Wuchow, on the West River, Kwangsi Province.

On analysis it gave the following results:—

Specific gravity at $\frac{15 \cdot 5^{\circ} \text{ C.}}{15 \cdot 5^{\circ} \text{ C.}}$ ...	0·918
Acid value ...	9·4
Saponification value ...	193·4
Iodine value ...	87·5

The oil was submitted to a firm of soap-makers, who stated that it made a softer soap than cotton-seed oil, and would therefore be worth about £1 per ton less than the latter, the current price of which was £22 2*s.* 6*d.* per ton in Hull (February 1912).

This oil would find a market in the United Kingdom for lubricating and soap-making purposes. The presence of saponin in the seeds, and sometimes in the oil, would, however, probably render the latter unsuitable for edible use.

Cake.—This material consists of the cake left on expressing the tea-seed oil described above from the seeds of *C. Sasanqua*.

The sample examined was in the form of hard, firm, circular cakes about 1 in. in thickness. It was dark brown, and possessed an unpleasant, pungent, bitter taste.

On examination it gave the following results:—

	Per cent.
Moisture ...	8·33
Crude proteins ...	6·49
True proteins ...	6·13
Other nitrogenous substances ...	0·36
Fat ...	1·31
Starch, etc. ...	43·24
Fibre ...	37·43
Ash ...	3·20

No alkaloids were present, but the material contained 7 to 8 per cent. of saponin.

This material cannot be used as a feeding cake, owing to the large amount of saponin it contains.

The cake is also unsuitable for use as a substitute for quillaia bark (soap bark), as it contains less saponin than the latter. It appeared, however, to be sufficiently rich in saponin to be of use in the preparation of vermicides for dressing lawns, and samples were accordingly submitted to two firms of manufacturing chemists, in order to ascertain its suitability for this purpose. Both firms reported favourably, and offered to purchase trial consignments of the cake.

CASTOR SEED.

UGANDA.

Nine samples of castor seed were received in October, 1910. They were as follows:—

No. 1. Bright brown and grey mottled seeds varying in size from small to medium. A few damaged seeds were present.

No. 2. Medium-sized seeds, of grey colour with very dark brown mottling. A few damaged seeds were present.

No. 3. Large grey and black mottled seeds. A few damaged seeds were present.

No. 4. Fairly large, elongated greyish-white seeds, lightly mottled with black. A fair number of broken seeds were present.

No. 5. Fairly large brownish-grey seeds, mottled with very dark brown. A very few damaged seeds were present.

No. 6. Small, greyish seeds, mottled with dark brown or black. A few damaged seeds were present.

No. 7. Dark greyish-brown mottled seeds of small to medium size. Hardly any broken seeds were present.

No. 8. Fairly large, broad seeds, of coppery-brown colour, lightly mottled with dark brown. Some broken seeds were present.

No. 9. Large, elongated white seeds, mottled with black or dark brown. Some broken seeds were present.

The yields of oil obtained from the samples by extraction were as follows:—

No. of Sample.	Yield of oil.	No. of Sample.	Yield of oil.
	Per cent.		Per cent.
1	48·0	6	48·9
2	50·8	7	47·6
3	49·4	8	45·
4	47·8	9	48·2
5	50·0		

These seeds would all be readily saleable in Europe. Their commercial value would approximate to that of Bombay castor seed, which at the time of the report was worth £12 5*s.* per ton in the United Kingdom (February 1911).

SUDAN.

The castor plant grows wild in the Sudan, and recently experimental plantations have been made on the Kassala farm with Indian and Java kinds, which have proved superior to the native plant. A variety with brilliant red seed spikes has also been introduced from Borgu in West Africa. It is said to be superior to the indigenous variety and to produce larger seeds. The following table gives the principal results obtained by the examination at the Imperial Institute of castor seed from the Sudan.

Date of Receipt.	Origin.	Description of Seed.	Percentage of oil in Seed.	Valuation.
November 1905	Berber Prov.	Small to medium, dull greyish-brown marbled seeds.	46·8	£11 to £12 per ton (April 1906).
" "	Dongola ...	Small, medium and large seeds, varying in colour from reddish-brown to dark greyish-brown.	47·9	
" "	Upper Nile Prov.	Small, greyish brown, marbled seeds.	45·2	
" "	Halfa ...	Medium dull greyish-brown, marbled seeds.	47·7	
July 1906 ...	Rumbek, Bahr-el-Ghazal Prov.	Small, light brown seeds.	44·2	Same as Bombay castor seed.
" " ...	Red Sea Prov.	Small, grey seeds.	47·0	5s. per ton more than Bombay castor seed.
" " ...	"	Small, dark grey seeds.	41·1	Same as Bombay castor seed.
" " ...	"	Small, blackish seeds, not in good condition	48·7	5s. per ton more than Bombay castor seed, if shipped in sound condition.
" " ...	"	Small, greyish-brown seeds.	47·0	5s. per ton more than Bombay castor seed.
January 1907...	Bahr-el-Ghazal Prov.	Small, dark brown seeds.	44·0	Same as Bombay castor seed.
February 1907	Kassala Prov.	Small, grey seeds...	42·0	Same as Bombay castor seed.
April 1907 ...	Not stated...	Small, greyish-brown seed.	47·0	About 5s. per ton more than Bombay castor seed.
May 1911 ...	Kordofan Prov.	Large, reddish-brown, mottled seeds.	50·0	Same as Bombay castor seed.
December 1911	Mongalla Prov.	Small, grey seed ...	43·3	£10 12s. 6d. per ton (Jan. 1912)

East Africa Protectorate.

Ten samples of castor seed grown in various parts of the East Africa Protectorate were forwarded for examination in December 1908, July 1910, and August 1911.

No. 1. "Embu." Large seeds of mixed colour; some small seeds were also present.

No. 2. "Embu." Small, dark brown, mottled seeds.

No. 3. "Kisumia." Large elongated seeds, mostly brownish, not mottled; other castor seeds of dark-brown colour also present.

No. 4. "Mjakifu." Large, mottled seeds, very dark brown to black in colour.

No. 5. "Mjbri." Small, mottled, dark-brown seeds.

No. 6. "Nakinene." Small, dark brown, mottled seeds.

No. 7. "Njegegeg." Small, dark brown, mottled seeds.

No. 8. "Karungu." Very small, greyish-brown, mottled seeds.

No. 9. "Grown on the Uasin-Gishu plateau." Large, dark purple-brown seeds, not mottled.

No. 10. "Fort Hall District." Mixed large and small, variously coloured seeds. It contained 49·2 per cent. of oil.

With the exception of No. 10 all the samples were too small for chemical examination, but specimens were submitted to commercial experts, who valued them as follows:—

Nos. 1, 3, 4 and 6 ...	£9 17s. 6d.	per ton	(March 1909)
Nos. 5 and 7 ...	£9 10s. 0d.	,,	,,
No. 2	£9 0s. 0d.	,,	,,
No. 8	£8 10s. 0d.	,,	,,
No. 9	£13 5s. 0d.	,,	(October 1910)
No. 10	£12 0s. 0d.	,,	(March 1912)

net weight including bags, delivered free ex ship Hull, less 2½ per cent. discount.

The prices quoted for all the samples were based on the current market value of East Indian castor seed.

These valuations were very satisfactory, the prices quoted for the majority of the samples being in advance of the current value of East Indian castor seed. Very large quantities of castor seed are said to be available in the East Africa Protectorate.

Rhodesia.

Eight samples of castor seed grown near Salisbury, Southern Rhodesia, were forwarded for examination to the Imperial Institute in August 1906.

The following table gives a description of the samples and the yield of oil in each case:—

	Yield of oil. Per cent.
No. 1. Large clean seeds, almost black ...	47·7
No. 2. Large clean seeds, black and white striped	49·6
No. 3. Large clean seeds, light brown	50·0
No. 4. Smaller seeds, clean, mixed colour ...	46·8

	Yield of oil. Per cent.
No. 5. Large clean seeds, light grey or almost white	41·6
No. 6. Large clean seeds, brown, slightly pink	50·0
No. 7. Large clean seeds, chocolate-brown ...	39·6
No. 8. Medium sized, clean seeds, dark brown	46·6

Commercial experts reported that the average value of these samples was about £12 per ton, delivered ex ship in Hull (February 1907).

A further sample of castor seed grown in Rhodesia was received for examination in September 1907. It consisted of large, bright brown seeds with a copper-like lustre and slight white markings. The seeds yielded 51·2 per cent. of oil of the usual appearance of castor oil but somewhat yellow. The results of an examination of the oil were as follows:—

Specific gravity at 15·5°/15·5° C.	0·963
Acid value...	1·6
Saponification value	183·0
Iodine value	90·0

The oil was completely soluble in two volumes of 90 per cent. alcohol.

The seeds were valued at £11 per ton, with East Indian castor seed a £10 15s. per ton (March 1908).

The seeds differed considerably in appearance from the castor seed of commerce, but plants raised from them at Kew have proved to be a form of *Ricinus communis*, the common castor plant. The unusual appearance of these seeds would not interfere with their sale.

A further sample of castor seed was received from Rhodesia in May 1910. It consisted of clean, dark brown, mottled seed with a few white and black seeds.

The kernels contained 68·7 per cent. of oil, equivalent to 52·2 per cent. calculated on the whole seeds.

The sample was regarded by experts as of the same value as Bombay castor seed.

Castor oil.—A sample of castor oil, prepared locally, was forwarded for examination from Rhodesia in 1905. It was labelled "No. 1. castor oil, grown and extracted in Rhodesia," and consisted of nearly colourless, very viscous, slightly turbid oil. On chemical examination it yielded the following results:—

Specific gravity at 15·5°/15·5° C....	0·959
Acid value	1·2
Acid value (calculated as oleic acid), per cent. ...	0·6
Saponification value	179·6
Iodine value	87·0

One part of the castor oil was found to dissolve in 5 parts of 90 per cent. alcohol to form a clear solution. These results indicated that the product was of good quality, although its value was diminished on account of its turbid condition. If rendered clear by filtration, its value in the opinion of commercial experts would be about £26 to £28 per ton (October 1905).

Mozambique.

The five samples of castor seed which are the subject of this report were forwarded to the Imperial Institute from Beira in December 1911. They were stated to have been collected in the eastern part of Mossurise, and it was desired to ascertain which of the five varieties gave the largest yield of oil, in order that its cultivation by the natives could be encouraged.

The samples of seed were as follows:—

No. 1. Brown mottled, small.
No. 2. Black mottled, medium size.
No. 3. Brown mottled, medium size.
No. 4. Light-coloured, mottled, large.
No. 5. Long, black, large.

It was stated that No. 5 is rare, and that No. 1 is the variety most commonly cultivated.

The samples were all in good condition and were found to give the following yields of oil:—

	Per cent.
No. 1.	41·9
No. 2.	47·0
No. 3.	43·5
No. 4.	49·6
No. 5.	47·1

The samples were all of satisfactory quality, and similar seed would be readily saleable in Europe. The prices realised would depend to some extent on the percentage of oil present, but would approximate to that of Bombay castor seed, the current value of which was £12 7*s*. 6*d*. per ton (May 1912). It will be seen that sample No. 4 gave the best yield of oil (49·6 per cent.), whilst Nos. 2 and 5 also gave very good yields (47·0 and 47·1 per cent.). The common variety, No. 1, contained the lowest percentage of oil in the series.

Mauritius.

Two samples of castor seed labelled "white variety" and "red variety," respectively, were received from Mauritius in April 1911.

The former consisted of medium-sized, dark brown, mottled, rather dull seed; a few black seeds and a small amount of broken shell were present in the sample.

The "red variety" resembled the "white variety" in colour, but was of brighter appearance and consisted of mixed, small, and medium-sized seeds.

The two samples yielded respectively 45·2 and 45·5 per cent. of oil, approximately equal to the yield obtained from castor seed examined in Mauritius in 1908 (see *Bulletin of the Imperial Institute*, 1909, **7**, 418). The oil possessed the usual characters of castor oil.

These seeds contained about the normal amount of oil, and would realise approximately the same price as Bombay castor seed, viz., £12 per ton in Hull (October 1911).

CEYLON.

In Ceylon the castor plant occurs as a weed in many places, and its cultivation is confined mainly to native compounds. Some experiments undertaken in the Royal Botanic Gardens, Peradeniya, have shown that its cultivation in that locality would be unremunerative although it might be made to pay in other parts of the Island. For these experiments seeds were obtained from Calcutta, Madras, Colombo and Hakgala. Samples of the seeds grown were forwarded to the Imperial Institute for examination and valuation, and were reported on as follows:—

No. 1. Madras variety, marked "4 E.S." The sample was of good quality, but had a somewhat large proportion of small seeds. It was about equal in value to that imported from Bombay.

No. 2. Patna variety, marked "6 E.S." These seeds were rather larger than those of the preceding sample. The commercial experts reported that they were of good quality and worth 1*s*. 3*d*. to 2*s*. 6*d*. per ton more than Bombay seed.

No. 3. Calcutta variety, marked "2 E.S." This sample was of fair quality, but contained a large proportion of seeds which were discoloured and possessed withered kernels. It was valued at from 2*s*. 6*d*. to 5*s*. per ton more than Bombay seed.

No. 4. Major variety, marked "8 E.S." These seeds were of large size, but were considered by experts to be immature, since the kernels were soft and pulpy and did not fill the husks. The ripe seeds would no doubt contain a larger proportion of oil than the present sample, and if in good, sound condition would be worth 7*s*. 6*d*. per ton more than Bombay seed.

FIJI.

Three samples of castor seed grown in Fiji were received at the Imperial Institute for examination in 1909, and were reported on as follows:—

No. 1. "Mexican variety." These were small, dark brown mottled seeds, containing 47·4 per cent. of oil.

No. 2. "Mexican variety." Large white seeds mottled with dark brown, containing 49·6 per cent. of oil.

No. 3. "Hawaiian variety." Medium-sized dark brown mottled seeds, similar to No. 1, but larger, containing 48·5 per cent. of oil.

Castor seed as represented by these samples would probably realise from £9 to £9 10*s*. per ton in London (May 1909).

SOLID OR SEMI-SOLID OILS OR FATS.

This important group includes palm oil, palm-kernel oil and coconut oil as its most typical members, to which may be added Shea butter and the Bassia fats though these are much less important than the first three.

These products are used for the manufacture of soap, candles and lubricants. Coconut and palm-kernel oils are also employed to a considerable extent in the manufacture of cooking fats and similar edible products.

The importance of these various fats as raw materials for industrial purposes may be gathered from the following figures showing the imports into the United Kingdom in 1911: palm oil, 87,114 tons valued at £2,697,997; coconut oil, 56,741 tons valued at £2,260,310.

INVESTIGATIONS IN CONNECTION WITH THE AFRICAN PALM-OIL INDUSTRY.

The African oil palm, *Elaeis guineensis*, is the source of a number of economic products. West African natives employ the leaves in constructing huts, the very young leaves (palm cabbage) as a vegetable, and the palm wine extracted from the growing bud of the tree as a beverage. The leaves yield an excellent fibre, but up to the present no economical method of extracting this has been devised (*Bulletin of the Imperial Institute*, 1903, **1**, 23, and 1907, **5**, 118). In international commerce the only oil-palm products of importance are palm oil and palm kernels, both of which are extracted from the fruits of the tree. The great importance of the palm-oil industry may be gauged from the figures given above for imports of crude palm oil to the United Kingdom. In spite of the magnitude of this industry it has long been recognised that the extraction of the oil, which until quite recently was carried on entirely by natives in West Africa, is managed in a very primitive and wasteful fashion. From time to time attention has been directed by investigators to the necessity of remedying this state of things, and in particular a considerable amount of attention has been devoted to the possibility of introducing machinery for the extraction of the oil and a considerable number of machines have been devised some of which are now in use in West Africa.

In this country some attention has been given during recent years to this subject as the result of enquiries emanating from importers of palm oil and palm kernels in Liverpool, and on the initiative of the Director of the Imperial Institute, systematic investigations were made in the British West African Colonies by the Inspector of Agriculture in West Africa and by Officers attached to the local Forestry and Agricultural Departments. These enquiries have been directed mainly to the following points: (1) the extent to which the areas occupied by the oil palm in West Africa are at present being worked for palm oil and palm kernels, (2) the relative values, as sources of these two products, of the several varieties of oil palm now known to exist, (3) the

distribution of these varieties in the different Colonies and Protectorates of British West Africa, and (4) the extent to which machinery is now being used in West Africa for the extraction of palm oil and kernels. As a result of these investigations a great deal of new information was obtained and a large number of samples of palm fruits, nuts, kernels and oil were sent to the Imperial Institute for examination, mainly with a view to determining whether the fruits of any one variety of oil palm exhibited such advantages in yield of oil or in ease of extraction as to warrant the planting of that variety in preference to others.

The data thus obtained have been utilised in the preparation of this article.

Distribution of the Oil Palm.

The oil palm is indigenous to West Africa, and occurs in the coast belt almost continuously from the French colony of Senegal to the Portuguese colony of Angola, or approximately from 16° N. lat. to 10° S. lat., but is found in greatest abundance from Sierra Leone to Kamerun. Inland it penetrates to great distances, and is found as far in the interior as the great lakes and occurs less frequently right across the continent and in the islands of Zanzibar and Pemba. Dense forests of oil palms are, however, only found in the coastal region, and in West Africa it does not occur thickly much beyond 200 miles from the coast. The commercial supplies of palm oil are obtained mainly from Southern Nigeria, Sierra Leone, the Gold Coast Colony, Dahomey, the French Congo, Kamerun, Togoland and Angola, whilst there have been in recent years small exports of palm kernels from the island of Pemba on the east coast and of palm oil from German East Africa, where oil palms occur in abundance along the shores of Lake Tanganyika, but owing to lack of transport facilities are not much worked for export.

In addition to these African sources the oil palm also occurs in Brazil, Guiana, the West Indies and Mexico. It has been introduced in the Federated Malay States, Borneo, Java, the Philippine Islands and other islands of the Pacific, and from time to time small quantities of oil and kernels have been exported from several of these countries, but at the present time none of them contributes important amounts to the commercial supply of these products.

Enquiries received recently at the Imperial Institute indicate that the question of cultivating the oil palm is being considered by planters, particularly in the Federated Malay States and in certain of the Pacific Islands. In forming such plantations it should be remembered that there are enormous areas covered by the oil palm in West Africa, the greater part of which, according to competent authorities, are as yet almost unworked. It is possible, however, that such plantations in suitable localities having a plentiful supply of cheap and intelligent labour, capable of using machinery for the extraction of oil and kernels, might be remunerative, but at present no definite data are available on this subject.

Description of the Tree.

The full-grown oil palm may attain a height of about sixty feet, and consists of a stem covered throughout its length with the bases of dead leaves, and bearing at the apex a crown of large, pinnate leaves, each of which may be fifteen feet in length with leaflets two or three feet long. The tree is very slow growing, and from measurements made in the Agege district of Southern Nigeria reaches a height of six to nine inches in three years, twelve to eighteen inches in four or five years, eight feet in ten years, and thirteen to fourteen feet in fifteen years, and it is estimated that it attains its full height of sixty feet in about one hundred and twenty years. The fruits are borne in large bunches termed "heads" or "hands," which are small and numerous when the tree first begins to bear (this varies from the fourth to the eighth year according to climatic conditions, etc.), but decrease in number and increase in size in the next few years; thus in Southern Nigeria, according to Thompson, as many as thirty "heads" may be formed at first, decreasing to anything between two and twelve as the tree ages. The fruits are usually from one to one and a half inches in length, and three-quarters to one inch in diameter and are roughly egg-shaped, the narrower end being the apex. The colour and size depend on the variety of oil palm, but usually the fruits are reddish-brown or orange in tint. The fruit is botanically a drupe, and consists of three well-marked portions. Outside is a layer varying in thickness and composed of a soft fibrous pulp (pericarp), carrying from fifty-five to sixty-five per cent. (see tables of analyses, pp. 517, 525) of an orange-coloured semi-solid fat, which when extracted constitutes the palm oil of commerce. Inside this pulp is the palm nut (endocarp), consisting of a hard woody shell, which may vary considerably in thickness, enclosing usually a single palm kernel, though sometimes two or even three are present; the kernel is the second useful product of the palm fruit, it is dark reddish-brown or almost black externally, and internally consists of a rather hard, white "flesh" loaded with oil, which when extracted constitutes the "palm-kernel oil" of commerce.

The tree will apparently grow on most soils which are capable of holding a fair quantity of moisture, but it is only on rich moist soils and in districts having a fairly high rainfall (50 to 70 inches on the average) that it gives good yields of fruit. Thus, in an article on the oil palm in Southern Nigeria (*Southern Nigeria Gazette*, 1908, No. 10, Suppl.), it is pointed out that the common variety is confined to the moist belts of country, and is most plentiful on the native farms and in the evergreen forests of the Niger Delta and some of the littoral districts of the Eastern province, where a heavy annual rainfall is experienced. In the hinterland of Southern Nigeria, where the rainfall is deficient the distribution of the tree follows the evergreen belts of the forest skirting the large streams. It is conspicuously absent from the impoverished grass-covered soils on which the fan palm typically occurs, indicating that a dry climate and poor soil do not suit it.

CULTIVATION OF THE OIL PALM.

In most parts of West Africa the tree is not regularly cultivated, the natives depending entirely on wild untended forests for their supplies of palm fruits, but in some districts, for example, in the Krobo district of the Gold Coast and in the Camayenne district of French Guinea, a good deal of care is expended by the natives on the groves of palm trees. As a rule, however, all that is done is to collect seedlings from the forest and to plant these on newly-farmed lands or in areas in which the trees have been destroyed by fire or in other ways. Generally these seedlings are not even spaced out at regular intervals, and the only care taken of them consists in cutting away the undergrowth so that it may not interfere with the development of the young plants. For transplanting in this way seedlings from two to three feet high should be selected, and the planting out should be done in the rainy season. M. Adam recommends that a space of from twenty to twenty-six feet should be left between each plant and the next, or more than this where a catch crop of maize or cassava is to be taken off the land as well. In Southern Nigeria it is often found that in areas, cleared for farming, large numbers of palms subsequently spring up in the course of a year or two, and these are often thinned out or transplanted all over the farm. In some districts of the Western province of Southern Nigeria a few of the leaves are removed each year from the crowns of the trees, by which means the yield of fruit is said to be increased by from twenty-five to fifty per cent. The native practice of tapping the tree for palm wine often leads to its destruction, and in French Guinea and Dahomey decrees have been issued forbidding this practice and also the cutting down of palm trees.

The oil palm is attacked by a considerable number of insect and fungoid pests. The leaves are frequently covered by lichens and are also attacked by a species of "rust," but the tree does not seem to suffer as the result of these growths. A borer, *Rhyncophorus phœnicis*, akin to the "coconut-palm borer," attacks the young shoots by boring into them to lay its eggs, and this, together with the damage caused by the larvæ feeding on the young leaves and succulent tissues, frequently causes the death of the tree. In Dahomey the trees are attacked by a species of *Oryctes* and also by *Aspidiotus destructor*, but these do not appear to cause much damage.

Bush fires are also destructive to the palm trees, especially to the young seedlings.

VARIETIES OF OIL PALM.

In 1851 Welwitsch described two varieties of oil palm, which he named *Elæis microsperma* and *Elæis macrosperma*, and since that date practically nothing was done in the way of differentiating the oil palms of West Africa until 1902, when Preuss published the results of his investigations of the varieties occurring in Kamerun (*Der Tropenpflanzer*, 1902, 6, 454), although the occurrence of three varieties in the Gold Coast was noted in 1889 in a report on "Economic Agriculture on the Gold Coast"

(*Papers relating to her Majesty's Colonial Possessions* No. 110, Gold Coast [C. 5987-40]). Since then numerous investigations on this subject have been made in the British, French and German West African possessions.

From an economic standpoint perhaps the most important fact established is the existence in all these countries of a variety yielding fruits containing thin- or soft-shelled nuts (endocarp), with a thick layer of oily pulp (pericarp). The importance of this arises from the fact that throughout West Africa the palm nuts are almost invariably cracked singly by hand, and since hundreds of thousands of tons of palm kernels are exported every year the expenditure of labour in cracking these nuts would be materially reduced if thin- or soft-shelled nuts were available in large quantities in place of the common thick-shelled variety.

In the following paragraphs an account of the palm-oil industry in some of the more important producing areas in British West Africa is given, together with such information as is available regarding the varieties known, and their relative economic values as sources of palm oil and kernels.

For more detailed information on this and other points connected with the industry throughout West Africa (British and Foreign) the following articles and notes in the *Bulletin of the Imperial Institute* should be consulted:—

Investigations in connection with the African Palm-oil Industry, Vol. VII. (1909), p. 357.

The African Palm-oil Industry, II., Vol. XI. (1913), p. 206.

A new Palm-nut cracking Machine, Vol. VIII. (1910), p. 58.

Utilisation of Palm Oil as an Edible Fat, Vol. IX. (1911), p. 60.

Ordinances relating to the Oil Palm Industry of Southern Nigeria, Vol. IX. (1911), p. 297.

Experimental cultivation of "Lisombé" Oil Palm in Kamerun, Vol. IX. (1911), p. 157.

Composition of Palm Fruits from Dahomey, Vol. IX. (1911), p. 158.

Extraction of Palm Oil and Kernels by Machinery, Vol. IX. (1911), p. 403; Vol. X. (1912), p. 492; Vol. XI. (1913), p. 155.

Exploitation of Palm Oil and Palm Kernels in the Belgian Congo, Vol. IX. (1911), p. 403.

Progress of the Palm Oil Industry in the Gold Coast, Vol. X. (1912), p. 316.

Cracking and Drying of Palm Nuts in Southern Nigeria, Vol. X. (1912), pp. 492, 668.

GAMBIA.

Little attention has been paid so far to the production of palm oil and palm kernels in this Colony, and the oil does not even seem to be extracted locally to any considerable extent by the natives for use as a cooking fat. Only one variety of the oil palm is known to exist, and that is most abundant in the Kommbo and Fogni provinces. The export of palm oil in 1911 amounted to 650 gallons valued at £46. Only small exports of palm kernels have been recorded in recent years, as the following table shows:—

Palm Kernels.

1908.	1909.	1910.	1911.
Tons. 391	Tons. 389	Tons. 467	Tons. 444
£ 3,488	£ 3,526	£ 5,640	£ 4,758

SIERRA LEONE.

The oil palm is very abundant in this Colony and the hinterland, so much so that in many parts, particularly in the Sherbro and Panguma districts, the population is insufficient to work the palms fully. Only one variety of palm occurs, and that is of the ordinary type having thick-shelled nuts. As is generally the case, the fruits even on the same tree show considerable variation, but the Inspector of Agriculture for West Africa, who has made careful investigations on this point, states that although different names are given by the natives to the fruit at different stages of growth, he was unable to find any evidence of the existence of more than one variety of palm, and this yielded a fruit having a thick-shelled nut and a thin pulp. The industry has shown considerable expansion since transport facilities were improved by the opening of the railway at the end of 1905. The exports of palm oil and kernels from the Colony in recent years are shown in the following table:—

—	1908.		1909.		1910.		1911.	
	Galls.	£	Galls.	£	Galls.	£	Galls.	£
Palm oil ...	489,637	36,451	851,998	64,273	645,339	62,852	725,648	69,927
	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Palm kernels	33,721	332,887	42,897	482,614	43,031	644,684	42,892	657,348

GOLD COAST COLONY

According to a report by Mr. A. E. Evans, Travelling Instructor in Agriculture in the Gold Coast, the oil palm is widely distributed in that Colony, but is most abundant in the Eastern and Central Provinces. A number of varieties of oil palm, falling into three main groups, have been recorded by the Agricultural Department. The following brief description of these may be given:—

Group 1.—Fruits large; colour of pericarps varies from yellowish-white to blackish-red; nuts hard.	"Abe-pa" "Abe-dam" "Abe-buntum" "Abe-fita" or "Abe-fufu" "Adi-be" "Abubu-be"

Of these the "Abe-pa" variety is said to be the most abundant and is widely distributed all over the Colony. The "Abe-dam" variety is very similar and also abundant; the "Abe-tuntum" fruits are nearly black in colour; the "Abé-fita" variety is very scarce; it bears large fruits with pericarps which are white with large dark red splotches, and yields hard nuts; the oil from this variety is of a characteristic pale canary colour, and differs slightly from the oils of other varieties examined in having a low iodine value, viz. 44·5, the usual value being approximately from 55 to 60. "Adi-be" is said to be scarce and to bear long fruits, with small hard nuts and very fleshy pericaps yielding 28 per cent. of oil when extracted by native methods. "Abubu-be" is also scarce; its fruits resemble those of "Abe-tuntum," but yield 25 per cent. of oil, whilst the fibre in the pericarps is said to be very short.

Group 2.—Fruits small; very fleshy pericarps, with thin soft-shelled nuts.	"Abobo-be."

This is the soft-shelled oil palm of the Gold Coast Colony. It is found in the Eastern and Central Provinces, but is not abundant. The shell of the nut can be readily cracked with the teeth.

Group 3.—Fruits large; pericarps brick-red; nuts hard; leaflets joined together at base.	"Abe-ohene" or King Palm.

The "Abe-ohene" or "King Palm" is exceedingly scarce, and has the same characteristics as the "King Palm" of Southern Nigeria (*i.e.*, the leaflets are joined together at the base), with which it is probably identical.

It is impossible as yet to correlate all these Gold Coast kinds with the varieties noted in other parts of West Africa, but the "Abobo-be" variety has fruits of medium size with thick pericarps and thin-shelled nuts, which resemble those of the "Lisombé" variety of Kamerun, and from comparison of the two made at the Imperial Institute there can be little doubt that this variety is the same as the "Lisombé." Mr. Evans has stated that "the form known as 'Abobo-be' in this Colony somewhat resembles that described by Dr. Preuss in Kamerun as 'Lisombé,' but I am inclined to think it must be a different species, as the 'Abobo-be' in this Colony is smaller than the other varieties, but has a much thicker fleshy pulp; the 'Lisombé' is said to be a much larger fruit, and Dr. Preuss states that the average weight of the 'Lisombé' fruit (arrived at from measurements of the contents of thirteen bunches) was 10·24 grams, whereas the average weight of 'Abobo-be' is only 6·25 grams."

Reference to the table of analyses in Dr. Preuss's article (*Der Tropenpflanzer*, 1902, 6, 465) shows that the "Lisombé" fruits vary in weight from 5·45 to 10·0 grams, so that the supposed difference referred to by Mr. Evans appears to be based on a misinterpretation of Dr. Preuss's results.

Variety and number of sample.	Group I. Abe-pa 27747. 1.	Abe-pa 27747. 2.	Abe-dam 27747. 1.	Abe-dam 27747. 2.	Abe-tuntum 27747. 1.	Abe-tuntum 27747. 2.	Abe-fita 25748 1.	Group II. Abubu-be 30348. 2.	Abobo-be 27747. 1.	Abobo-be 31137. 2.	"Seedless" 29031.* 2.	Unclassified. Cross between Abobo-be and Abe-dam 27747. 2.
FRUITS:												
Dimensions — Average length, inches	1·55	1·2	1·15	1·15	1·25	1·25	1·5	1·30	1·2	1·05	0·8	1·35
„ diameter, inches	0·95	0·8	0·80	0·7	0·8	0·8	1·25	0·75	0·8	0·65	0·4	0·7
„ weight, grams	12·2	7·0	8·7	5·3	7·7	7·1	—	5·9	6·8	3·45	a=0·5 b=4·4	5·8
Composition — Pulp, per cent.	31	29	41	34	29	36	—	50	63	69	—	51
Nuts, per cent.	69	71	59	66	71	64	—	50	37	31	—	49
PULP:												
Composition — Moisture, per cent.	13·6	16·3	25·5	13·5	38·8	31·1	—	21·7	24	24·1	11·1	23·8
Oil, per cent., calculated on moist pulp ...	69·2	65	59·7	68·6	39·4	†18·7	—	62·1	[illegible]	64·1	76	59·5
„ „ calculated on dry pulp ..	80·0	77·6	80·0	79	65·7	70·5	—	79·3	75·6	84·4	85	77·6
NUTS:												
Dimensions — Average length, inches	1·2	1·0	(1) 1·0 (2) 0·8	0·9	1·0	0·95	1·25	1·0	0·75	0·50	—	0·95
„ diameter, inches	0·85	0·7	(1) 1·0 (2) 0·8	0·65	0·7	0·7	0·7	0·63	0·6	0·42	—	0·60
„ weight, grams	8·3	4·4	5·3	3·4	4·8	4·5	—	3·03	2·5	1·1	—	2·8
„ thickness of shell, inches ...	—	0·15	—	0·13	—	0·15	0·17	0·08	0·05	0·04	—	0·10
Composition — Kernel, per cent.	25	31	31	23	24	28	—	40	54	53	—	42
Shell, per cent.	75	69	69	77	76	72	—	60	46	47	—	58
KERNELS:												
Dimensions — Average length, inches	0·8	0·7	(1)0·6 (2)0·75	0·55	0·6	0·6	0·7	0·6	0·55	0·40	—	0·65
„ diameter, inches	0·55	0·4	(1)0·6 (2)0·5	0·40	0·45	0·4	0·35	0·47	0·50	0·35	—	0·40
„ weight, grams	2·1	1·6	1·65	0·8	1·2	1·2	—	1·16	1·4	0·45	—	0·95
Composition — Moisture, per cent.	23·7	20·0	20·6	19·6	21·7	22·6	—	21·5	27	—	—	22·2
Oil, per cent., calculated on moist kernels	—	41·0	—	43·6	—	44·0	—	44·4	—	—	—	42
„ „ calculated on dry kernels	—	51·0	—	54	—	57·0	—	56·6	—	—	—	54

Note.—The results of examination recorded in each case under No. 1 are for small samples received preserved in formalin, and under No. 2 for large samples of fruits received packed in damp sawdust: the results for No. 2 are therefore the more trustworthy indication of the *average* size and composition of the fruits in question.

* Out of 30 fruits only 6 contained nuts; these were very small and about 0·25 inch in diameter. "*a*" in this column is the weight of a small fruit, and "*b*" that of a large one.

† Received in somewhat poor condition.

In addition to the varieties described above, the Director of Agriculture in the Gold Coast subsequently transmitted to the Imperial Institute a small sample of a "seedless" oil-palm fruit. This appears to be identical with the "Votchi" of Dahomey, but nothing is yet known as to the extent of its occurrence in the Colony.

Samples of the fruits, nuts, kernels and oils obtained from a number of these Gold Coast varieties of oil palm have been examined at the Imperial Institute, and the results are given in the tables on pp. 517 and 519.

Practical trials of the fruits of five of these varieties have been made in the Gold Coast by Mr. Evans, using ordinary native methods of extraction, and these have given the results quoted below, to which are added, for comparison, the actual percentages of palm oil present in the fruits, as deduced from the analytical results obtained at the Imperial Institute.

	Variety.	Palm oil in *whole* fruits as received at the Imperial Institute (calculated).	Yield of palm oil obtained by native methods.	Kernels in fruits as received at the Imperial Institute.	Approximate thickness of shells of nuts.
		Per cent.	Per cent.	Per cent.	Inch.
Group I.	Abe-pa	19	11·2	22	0·15
	Abe-dam ...	23	11·2	15	0·13
	Abe-tuntum ...	17	13·7	18	0·15
	Abe fita	—	—	—	0·17
	Abubu-be ...	31	—	21	0·08
Group II.	Abobo-be ...	44	19·2	20	0·05
	"Seedless" ...	76	38·5	—	—*
Unclassified.	Cross between Abe dam and Abobo-be ...	31	—	21	0·10

* See foot-note to previous table as regards nuts in this variety.

From the tabulated results it is obvious that "Abobo-be" is superior to all the other Gold Coast varieties, with the exception of the "seedless" kind, in yield of palm oil, and at the same time gives a high yield of kernels, and further, the shells being thin, the nuts are easier to crack. It should be noted, however, that the nuts, and consequently the kernels, are much smaller than those of the other varieties, and although less force is required to crack the nuts, a much larger number must be cracked to obtain the same weight of kernels than is the case with nuts from some of the other kinds of palm fruits. Little or no attention has been given to this point previously, and it would be interesting to know whether a larger amount of kernels could be obtained from the thin-shelled varieties than from the thick-

shelled kinds in a given time with the same amount of labour. From the dimensions, appearance and composition of the "Abobo-be" fruits there can be no doubt that they are identical with the "Lisombé" and "A-sog-e-jub" fruits of Kamerun and Southern Nigeria (p. 524) respectively. Of the other varieties there is not very much to choose between the "supposed cross between Abobo-be and Abe-dam" and "Abubu-be," all of which give fair yields of oil and kernels, but have shells of a thickness intermediate between the typical thin-shelled variety "Abobo-be" and the typical thick-shelled variety, "Abe-pa."

"Abe-dam," "Abe-pa" and "Abe-tuntum" are all poor varieties and differ but little in yield of oil and kernels, and it is rather difficult to see how they can be differentiated, since although the colour and shape of the fruits vary it seems that these characteristics are too uncertain to be of much value (Thompson, *Southern Nigeria Gazette*, 1909, No. 38, Suppl. xxv.). "Abe-fita" is also a poor variety, and has nuts with thick shells. It is interesting, as it yields a pale-coloured oil slightly different from the others in chemical composition, but as it is rare it is unlikely to be of any special value. The so-called "seedless" variety yields a large amount of palm oil, but it is rare, and it is not known whether it can be grown from the small seeds, which some of the fruits contain. It appears to resemble the "Votchi" variety from Dahomey.

Comparison with the table of analyses on p. 525 shows that in most cases the average weights of fruits from the Gold Coast are smaller than those of similar varieties from Southern Nigeria, presumably owing to less favourable conditions of growth. This is especially noticeable when the fruits of the "Abobo-be" variety of the Gold Coast (weighing from 3·45 to 6·8 grams) are compared with the fruits of the corresponding thin-shelled sort, "A-sog-e-jub," from Southern Nigeria (weighing 12·6 grams). The weights of the Gold Coast fruits approximate to those of the corresponding Togoland varieties as recorded by Fendler (*Arbeiten Pharm. Inst. Berl.* Vol. i, p. 192).

Gold Coast Palm Oils.

The results of examination of palm oils prepared in the Gold Coast Colony by the usual native methods from fruits of several varieties of oil palms as well as of oils extracted at the Imperial Institute by light petroleum are given in the following table:—

—	Abe-pa.		Abe-dam.			Abe-tuntum.		Abe-fita.		Abobo be.		"Seedless."		Adube.
	1.	2.	1.	2.	3*.	1.	2.	1.	2.	1.	2.	1.	2*.	
Specific gravity at 100°/15·5° C.	0·861	0·861	0·862	0·860	0·859	0·868	0·860	0·860	0·859	0·862	0·861	0·860	0·850	0·861
Acid value... ...	5·3	9·8	12·0	2·4	72·0	6·0	11·8	9·2	12·9	10·8	8·0	19·8	90·4	4·7
Saponification value.	196·5	197·0	196·5	195·5	199·0	195·5	197·0	198·5	198·5	194·0	195·5	197·5	199·0	197·0
Iodine value ...	58·3	50·0	57·8	54·0	59·0	59·5	49·6	44·5	44·8	61·3	54·0	55·5	56·5	57·6
Reichert-Meissl value.	—	—	—	—	—	—	—	0·2	—	0·2	—	—	—	—
Titer test	—	—	—	—	—	—	—	41·5	—	48·3	—	—	—	—
Unsaponifiable matter.	—	—	—	—	—	1·0	1·0	1·3	—	2·0	—	—	—	—

* *Oil extracted at the Imperial Institute by light petroleum.*

With the exception of the "Abe-fita" oil (which is of pale yellow colour and has a low iodine value), the chemical composition of the oils derived from the different varieties of fruits has been found to be the same. The similar investigations of Togoland oils made by Fendler (*loc. cit.*, p. 194) led to the same result.

The exports of palm oil and palm kernels from the Gold Coast Colony in recent years are given in the following table:—

—	1909.		1910.		1911.	
Palm oil ...	Galls. 2,007,293	£ 120,978	Galls. 2,044,868	£ 161,388	Galls. 1,610,209	£ 128,916
Palm kernels...	Tons. 11,598	£ 112,425	Tons. 14,182	£ 185,058	Tons 13,254	£ 175,891

[ADDENDUM.] Since the date of the above report (February, 1910) further samples of oil palm products have been received from the Gold Coast for examination, and the results of this work are summarised in the following paragraphs.

The materials received in recent years from the Gold Coast include fruits of two varieties of oil palm not described above, oil and residual fibre produced in experiments with the Gwira pulping machine, specimens of the fruits used in one of these experiments, and oils obtained in the course of fermentation experiments.

"*Adi-be*" *Palm Fruits.*—This consisted of a mixture of large and small fruits, which had been gathered from one bunch.

The large fruits had thick pulp and contained medium-sized nuts resembling those of "Abobo-be" palm fruits (p. 516) with thin shells and globular kernels. The small fruits were narrow and elongated, containing no nuts but only a small fibrous mass at the centre. They resembled immature fruits as found in most heads of palm fruits, but the "embryo" nut was smaller.

The size and weight of the fruits were as follows:—

—		Large fruits.			Small fruits.
		Fruits.	Nuts.	Kernels.	
Average length	inches	1·4	0·7	0·50	1·05
Average diameter	"	0·8	0·6	0·45	0·40
Average thickness of shell ...	"	About 0·05 and less			—
Average weight	grams	6·7	2·5	1·1	1·5

A mixture of large and small fruits in the proportion of 2 to 3, as in the sample received, was found to have the following composition: The fruit contained 72 per cent. pulp, 28 per cent. nut, and 12·5 per cent. kernel. The pulp of the fruit contained 14·5 per cent. moisture and 62·2 per cent. oil (equivalent to 44·8 per cent. in the whole fruit and 72·7 per cent. in the dry pulp). The nuts contained 55 per cent. shell and 45 per cent. kernel. The amount

of moisture and oil in the kernels could not be determined owing to the small size of the sample.

This fruit is a thin-shelled variety, which would give a good yield of palm oil and a fair yield of kernels. It would be of interest to know if the relative proportions of large fruits with nuts to small fruits without nuts is naturally the same as in the sample supplied.

"*Abe-dam-Adi-be*" *Palm Fruits.*—This variety derives its name from the fact that the fruits are pale in colour like those of "Abe-dam," and possess a thick pulp like those of "Adi-be." It may be a hybrid between these forms, but both of these varieties have thick, hard endocarps, whilst the present example is practically "shell-less," as mentioned below. So far only one tree of this variety has been seen, which is growing at a village near Aburi.

The sample consisted of somewhat small palm fruits, resembling "Abobo-be" fruits in shape and general structure, except that the kernels in most cases had no hard, woody shell, but only a very thin, brown coat or a thin layer of dark brown fibres surrounding them. A very few of the fruits contained nuts with a very thin, brittle shell, but for practical purposes they may be termed "shell-less." The kernels were small and almost spherical.

The average lengths of the fruits and kernels were 1·25 in. and 0·50 in. respectively; the average diameters 0·65 in. and 0·43 in.; and the average weights 3·95 and 0·75 grams. The proportion of pulp in the fruits amounted to 82 per cent., and it contained 27·7 per cent. moisture and 50·9 per cent. oil (equivalent to 41·7 per cent. in the whole fruits and 70·2 per cent. in the dried pulp). The quantity was too small to allow of determination of the amount of moisture and oil in the kernels. It has, however, been shown by previous analyses that the percentage of oil in the kernels of different varieties of palm fruit only varies between narrow limits (see p. 517).

These palm fruits gave a good yield of oil and a fair yield of kernels. The economic importance of the variety will, however, depend entirely on the possibility of reproducing it from seed.

Experiments with the Gwira Pulping Machine.—An experiment with this machine was conducted in the Gold Coast in 1910. Sixty pounds of fresh palm fruits yielded 15·52 per cent. of oil, 58·33 per cent. of nuts, and 10 per cent. of fibrous residue, the loss being 16·14 per cent. A sample of the oil and one of the fibrous residue, as collected from the machine, have been examined at the Imperial Institute.

The oil was clean, orange-red in colour, and of good quality. It contained only 0·85 per cent. of moisture and 0·03 per cent. of impurity.

The following results were obtained on examination:—

Specific gravity at $\frac{100° \text{ C.}}{15·5° \text{ C.}}$	0·858
Acid value	10·4
Saponification value	199·7
Iodine value	51·0
Titer test	43·5° C.

This oil had the usual chemical characters of good-quality palm oil. It was of good colour, and free from any appreciable amount of moisture or dirt, and such palm oil would be readily saleable in Europe, at good prices, as "soft" palm oil.

The fibrous residue was found to contain 9·6 per cent. of moisture and 34·2 per cent. of oil, or 37·8 per cent. calculated on the dry material. The oil, as extracted by solvents from the fibrous residue, was hard and of pale colour, and consisted chiefly of fatty acids.

Residual fibrous pulp obtained in the extraction of palm oil by the usual native method in Southern Nigeria, examined at the Imperial Institute, contained only 34 per cent. of oil, calculated on the dry material, as compared with 37·8 per cent. in the present instance. The fibrous pulp from Southern Nigeria was obtained in the extraction of palm oil by the usual native method, and it would thus appear that the Gwira machine does not extract as large a proportion of the oil from palm fruits as the native process does. This is probably due to the fact that no pressure is exerted on the pulp in the machine, the oil being merely washed out, whereas in the native process the pulp is squeezed by hand. Some of the oil retained in the present sample of machine-prepared fibrous residue was readily extracted by wrapping the material in a cloth, immersing for a few minutes in boiling water, and wringing by hand.

The bulky, fibrous nature of this residual pulp renders complete extraction of the oil by mechanical means impossible, but it should be easy to obtain a good yield of oil by re-heating the material with water and subjecting it to pressure in simple screw, lever, or wedge presses, or even by hand.

A second experiment was carried out in 1912, the materials employed consisting of equal quantities of the fruits of the "Abe-pa," "Abe-dam," and "Abe-tuntum" varieties. Five lots of fruits, each lot weighing 80 lb., were pulped. The fibre and nuts were washed after coming from the machine, and the oil and water squeezed from the fibre by hand. The yield of oil ranged from 13·75 to 16·25 per cent., and the percentage of fibrous residue from 7·50 to 10·0. A sample, representative of the fruits used in this experiment, and some of the fibrous residue obtained, were received for examination.

The palm fruits were orange-red in colour, in good condition, with thin pulp and thick-shelled nuts. The pulp formed 30 to 31 per cent., and the nuts 69 to 70 per cent. by weight of the fruits; the nuts consisted of 70 per cent. of shells and 30 per cent. of kernels. These proportions of shell and kernel agree with the results obtained for samples of thick-shelled palm nuts previously examined at the Imperial Institute (see p. 517).

The pulp of the fruits as received contained 5 per cent. of moisture, and 72·1 per cent. of oil, equivalent to 75·8 per cent. of oil in the dry pulp. In the case of previous samples of palm fruits examined at the Imperial Institute, the pulp has contained as much as 31 per cent. of moisture, and even this is probably exceeded in the freshly-gathered fruit, so that it is clear that the sample under report had dried considerably during transit to

London. It may be pointed out that the amount of moisture present in the fruits when pressed must be taken into account when comparing the yields of oil in different instances.

The fibrous material was found to contain 10 per cent. of moisture, and 36 per cent. of oil, equivalent to 40 per cent. in the dry fibre. The fibre therefore contained rather more oil than that obtained in the previous experiment with the Gwira machine, and considerably more than the residue obtained by the usual native method of pressing palm fruits (see p. 522). The samples so far examined at the Imperial Institute have therefore not indicated that the Gwira machine extracts as much of the oil from the palm fruits as the usual native method.

Palm Oils obtained in Fermentation Experiments.—An experiment designed to ascertain the effect of fermentation of the fruit on the quantity and quality of the oil was carried out by the Agricultural Department, Gold Coast, in 1912. The yield of oil, as obtained by the Gwira machine, was as follows: From fresh fruits extracted on the day of gathering, 10 per cent.; from fruits fermented for eight days before extraction, 11·25 per cent.; from fruits fermented for six weeks, 9·82 per cent. The yield in each case was low, and further experiments are necessary before the results can be taken as decisive.

A sample of each of these oils was received at the Imperial Institute for examination. The oil prepared from fresh fruits and that prepared from fruits fermented for eight days were soft and had the normal appearance of palm oil; that prepared from fruits fermented for six weeks also had the appearance of palm oil, but it was much harder than the other samples.

In order to ascertain the effect of the fermentation on the composition of the oil, the acid values of the three samples were determined. This constant indicates the extent to which the oil has become rancid and "hard." The following results were obtained:—

	Acid value.
Oil from fresh fruits	8·4
Oil from fruits fermented 8 days ...	13·2
,, ,, ,, 6 weeks ...	103·7

These figures show that the first two are "soft" oils with a low acid value, whilst the third is a "hard" oil with a high acid value. For comparison with the above results the following acid values, recorded for typical "soft" and "hard" commercial palm oils, may be quoted:—

"Soft": Lagos palm oil... ...	25 to 26
"Hard": Congo ,, ...	151 to 167

The value of "hard" oil is much lower than that of "soft" oil, as will be seen by the following prices recently quoted in Liverpool: Lagos, "soft" oil, £31 5*s*. to £31 7*s*. 6*d*. per ton; Congo, "hard" oil, £26 to £26 5*s*. per ton (April, 1913).

The results of this investigation conclusively show that the effect of allowing palm fruits to ferment for a considerable period is to produce a "hard" oil of much lower commercial value than the "soft" oil prepared from the fresh fruits.

Northern Nigeria.

Comparatively little information is available regarding the distribution of the oil palm in this Protectorate. Palm oil and palm kernels are produced for local use, but owing to the distance from the coast only small quantities are exported through Southern Nigeria, the export returns being included with those for the latter colony.

Southern Nigeria.

Several varieties of oil palm have been observed in Southern Nigeria, and the fruits from those occurring in the Central, Eastern and Western Provinces have been examined at the Imperial Institute. According to Thompson three varieties are known (*Southern Nigeria Gazette*, Suppl., 1909, **4**, p. xxiv.). The following descriptions may be given:—

No. 1. This bears the following native names: "Ope-arunfo" (Yoruba dialect), "A-sog-e-jub" or "Osok-Eyop" (Efik dialect), "Osuku" or "Au-su-ku" (Ibo dialect), "Ivioronmila" (Benin dialect), "Eduege-Eyop" (Ibibio dialect). A thin-shelled variety found in all three provinces, but the proportion in which it occurs varies greatly, rising from 0·2 per cent. in the Western Province to 30 per cent. in the Eastern Province. It is said to give a larger yield of better oil than any of the others found in Southern Nigeria.

No. 2. This is the typical or ordinary oil palm of the country, and bears the following native names: "Ope-pankora" (Yoruba dialect), "Ak-por-ro-jub" or "Okporo-Eyop" (Efik dialect), "Ok-po-ruk-pu" (Ibo dialect), "Udin" (Benin dialect), and "Ikrok-Eyop" (Ibibio dialect). It forms about 60 per cent. of the oil palms in the Eastern Province.

No. 3. This appears to be similar to the "King or Fetish Palm" found in other parts of West Africa, since, like it, the leaflets are in many cases joined together. It is known by the following names: "Ope-Ifa" (Yoruba dialect), "Ogiedi" or "Ogedudin" (Benin dialect), "Af-fia-ko-jub" or "Afia-Okpo-Eyop" (Efik dialect), or "Ojina" or "O-ju-ku" (Ibo dialect), and "Efiako-Eyop" (Ibibio dialect). It is common near Lagos in the sandy country near the seashore and the lagoons, and is regarded as sacred by Yorubas; the nuts are used by native medicine men for casting lots.

In the tables on pp. 525, 526 are given the results obtained by the examination at the Imperial Institute of fruits, nuts and kernels of varieties from the Central, Eastern and Western Provinces.

From the data given in this table the factors of principal importance to the palm-oil industry may be obtained respecting each variety of fruit, viz., palm-oil content, palm-kernel content and approximate thickness of shells of nuts. As noted already in connection with the analyses of fruits from the Gold Coast, the moisture content of the palm fruits as received at the Imperial Institute from Southern Nigeria may differ considerably from that present in the fresh fruits as used by the natives for preparing palm oil, so that the oil content given in the table on p. 525 does not necessarily represent that of the fresh moist fruits.

Variety and number of sample.	Iviorunmila (Central Province) No. 27959.		A-sog-e-jub or Au-su-ku (Eastern Province) No. 30185.		Ope-pankora (Western Province) No. 30081.	Udin (Central Province) No. 27959.			Ak-por-ro-jub or Ok-po-ruk-pu (Eastern Province) No. 30185.		Ogiedi (Central Province) No. 27959.		Af-fia-ko-jub or O-ju-ku (Eastern Province) No. 30185.	
FRUITS:														
Dimensions — Average length, inches	small fruits; large .. 1·6		1·32		1·2	1·3			1·54		1·5		1·72	
" diameter, inches...	small .. 0·45; large .. 1·15		0·95		0·83	0·85			0·95		0·65		0·90	
" weight, grams ...	small .. 3·0; large .. 10·0		12·6		7·4	7·1			12·8		4·3		12·60	
Composition — Pulp, per cent.	26		83		36	25			45		53		69	
Nuts, per cent.	74		17		64	75			55		47		31	
PULP:														
Composition — Moisture, per cent.	5·5		25·6		25·1	6·4			29·8		7·1		28·6	
Oil, per cent., calculated on moist pulp...	67·1		58·7		54·0	66·0			58·2		66·7		54·9	
" " calculated on dry pulp ...	71		78·9		72·0	70·5			83·1		71·8		76·9	
	A	B	A	B		A	B	C	A	B	A	B	A	B
NUTS:														
Dimensions — Average length, inches	small 0·6; large 1·4	—	0·82	—	0·90	1·0	—	—	1·32	—	0·62	—	1·07	—
" diameter, inches...	small 0·4; large 0·8	—	0·56	—	0·70	0·75	—		0·78	—	0·5[illegible]	—	[illegible]64	—
" weight, grams	3·6	5·0	2·05	2·46	4·9	5·5	4·02	—	7·6	7·0	2·15	small 1·0; large 6·4	4·0	4·5
Composition — Kernel, per cent.	—	21	53	40	30	—	18	—	20	19	—	18	37	25
Shell, per cent.	—	79	47	60	70	—	82	—	80	81	—	82	63	75
KERNELS:														
Dimensions — Average length, inches	small 0·1; large 0·9	—	0·53	—	0·60	0·56	—	—	0·70	—	0·5	—	0·65	—
" diameter, inches...	small 0·3; large 0·5	—	0·43	—	0·48	0·50	—	—	0·47	—	0·36	—	0·50	—
" weight, grams	—	1·0	1·0	1·0	1·48	—	—	0·88	1·5	1.3	—	0·44	1·3	1·1
Composition — Moisture, per cent....	7·2	—	18·9	—	—	8·3	—	6·7	20·2	—	8·0	6·4	22·0	—
Oil, per cent., calculated on moist kernels	48·8	—	—	—	—	—	—	49·7	—	—	48·5	50·6	—	—
" " calculated on dry kernels	52·5	—	—	—	—	—	—	53·4	—	—	52·7	54·0	—	—

Note.—Column A gives in each case results of the examination of palm nuts extracted from fruits as received at the Imperial Institute from S. Nigeria.
Column B gives in each case results of the examination of palm nuts as received from S. Nigeria.
Column C gives results of examination of palm kernels as received from S. Nigeria.

These results show that "Ope-pankora" fruits from the Western Province are medium-sized, irregularly-shaped fruits of the common thick-shelled variety, and are evidently a poor variety giving low yields of oil and kernels. Of the three kinds sent from the Central Province all had evidently dried *en route*, and the results are therefore only approximate and of less value than results from fruits in a natural moist state would have been. The "Ivioronmila" fruits were in somewhat poor condition, and very irregular in size and weight; they had mostly thick-shelled nuts and a thin pulp, although some of the smaller fruits had somewhat thin-shelled nuts. Thompson (*loc. cit.*) classes this as a thin-shelled kind; this is evidently not true of all the sample sent to the Imperial Institute. The sample of "Ogiedi" fruits contained two kinds, (1) elongated fruits of curious shape with thick pulp

Variety.	Palm oil in fruits as received at the Imperial Institute (calculated).	Kernels in fruit as received at the Imperial Institute.	Approximate thickness of nut shells.
	Per cent.	*Per cent.*	*Inches.*
Ope-pankora. Western Province ...	19	19	0·10
Udin. Central Province ...	16	13	0·20
Ak-por-ro-jub or Ok-po-ruk-pu. Eastern Province ...	26	moist, 11·0; dry, 10·5	0·15
Ivioronmila. Central Province ...	17	15	nuts from small fruit, 0·05; large fruit, 0·20.
A-sog-e-jub or Au-su-ku. Eastern Province ...	48	moist, 9·0; dry, 7·0	0·06
Ogiedi. Central Province ...	35	8	0·07*; 0·15†
Af-fia-ko-jub or O-ju-ku. Eastern Province ...	38	moist, 11·5; dry, 7·8	0·08

* Small sample of broken shells received from S. Nigeria.
† Shells of nuts extracted from fruits received from S. Nigeria.

and thin-shelled nuts, (resembling those of "Abobo-be" (p. 516), or "Lisombé," (2) fruits with thin pulp and thick-shelled nuts; no nuts could be found showing the four eyes, which are said to be characteristic of this variety (*Kew Bulletin*, 1909, 49), but a small sample of "Ope-ifa" palm fruits from Abuleoja examined contained some nuts with four and even five eyes. It would be interesting to know whether the mixed nature of these samples of "Ivioronmila" and "Ogiedi" fruits and nuts is due to natural variation or accidental admixture of different varieties during col-

lection. The "Udin" fruits were very similar in appearance to the larger fruits of the "Ivioronmila" variety, and do not differ appreciably from these in yield of oil and kernels.

Of the varieties from the Eastern Province the "A-sog-e-jub" or "Au-su-ku" fruits gave the best yield of oil of any of the Southern Nigerian varieties so far examined. The nuts are thin-shelled and yield fair-sized kernels, although the yield of kernels as calculated on the weight of fruit taken is not larger than those of the "Lisombé" and "Abobo-be" varieties, though the fruits are larger, probably owing to more favourable conditions of growth. There can be no doubt that "Abobo-be," "Lisombé" and "A-sog-e-jub" are all of the same type. The "Af-fia-ko-jub" or King Palm fruits furnish the same amount of kernels, but a better yield of oil than the typical thick-shelled "Ak-por-ro-jub." The latter resembles in general character the typical thick-shelled "Abe-pa" and "Abe-dam" varieties of the Gold Coast.

Palm oils from Southern Nigeria.

A number of these on examination proved to be quite similar in composition to palm oil of commerce, and, as in the case of all the Gold Coast kinds except "Abe-fita" oil, no difference in composition could be detected between palm oils from the different varieties of fruits. The results of examination of the Southern Nigerian palm oils are shown in the following table:—

	A-sog-e-jub or Au-su ku.	Udin.	Ak-po ro-jub or Ok-po-ruk-pu.	Ogiedi.	Af-fia-ko-jub or O-ju-ku.
Specific gravity at 100/15° C. ...	0·859	0·858	0·860	0·859	0·859
Acid value	11·0	17·2	9·7	7·7	9·5
Saponification value	201	199	197	198	200
Iodine value	49·6	56·3	53·6	54	52·4

[ADDENDUM.] Since the date of the above report (March, 1910) further samples of oil-palm products have been received from Southern Nigeria and these are dealt with below.

The oil-palm products received for examination from Southern Nigeria in recent years have included fruits of a new variety of oil palm and nine samples of palm oil. The latter were collected by Mr. J. H. J. Farquhar, of the Forest Department in Southern Nigeria, in the course of an enquiry into the palm-oil industry of the country.

The results of Mr. Farquhar's enquiry have been embodied in a report, entitled *The Oil Palm and its Varieties*, published recently. Mr. Farquhar refers the oil palms occurring in Southern Nigeria to two groups: (i) the King Palm (*Elæis guineensis* var. *Thompsonii* and (ii) the type form of *E. guineensis*, of which two sub-varieties are recognised.

The King Palm is a well-known form, and has been recognised by most writers as distinct from the ordinary oil palm and by some

is regarded as a separate species. It occurs in Southern Nigeria, chiefly in the sandy country bordering the seashore and lagoons, and is common in the vicinity of Lagos. It is not found in the dry zone, and is very scarce in the Central Province. Where found at all it constitutes not more than 15 per cent. of the total number of oil palms in the locality. The forms known to the Yorubas as "Ope-Ifa" and to the Benins as "Iviofounmila" are regarded by Mr. Farquhar as belonging to this variety.

The type form of *E. guineensis* is the ordinary thick-shelled variety of West Africa and is apparently identical with the *E. guineensis* var. *macrosperma* of Welwitsch. It includes those palms known to the natives as "Ope pankora" (Yoruba dialect), "Ak-po-ro-jub" and "Okporo-Eyop" (Efik), "Ok-po-ruk-pu" (Ibo), "Udin" (Benin), and "Ikrok-Eyop" (Ibibio). Mr. Farquhar considers that this palm comprises at least 98 per cent. of the total number of oil palms in Southern Nigeria, and possibly nearer 99·8 per cent.

The first sub-variety of the type form appears to be identical with the *E. guineensis* var. *macrosperma* of Welwitsch, the "Abobo-be" palm of the Gold Coast, and the "Lisombé" variety of Kamerun. The palms known as "Ope-arunfo" (Yoruba dialect), "A-sog-e-jub" and "Osok-Eyop" (Efik), "Osuku" and "Au-suk-ku" (Ibo), "Eduege-Eyop" (Ibibio), and "Ogiedi" (Benin), are regarded as belonging to this variety. It is distinguished from the other forms only by the character of its fruit, which is twice as long as broad, and dark claret-brown in colour when ripe, except at the point of attachment, which is yellowish-red; the mesocarp is thick and fleshy, the shell thin, and both nut and kernel are round. This palm is considered to be very rare, not exceeding 0·2 per cent. of the total number of palms in Southern Nigeria. It is most common in the Eastern Province and less plentiful in the Central Province, and appears to favour the rich alluvial land of the forest region, which has a heavy well-distributed rainfall.

The second sub-variety includes the "O-ju-ku" palm of the Ibos and the "Af-fia-ko-jub" of the Efiks. It is considered that 1·8 per cent. of the palms of Southern Nigeria belong to this class. The fruit is pale yellow in colour, shading into a coppery hue when ripe; the kernel is larger than in the type, the shell thicker, and the mesocarp thinner and lighter in colour.

Palm Oils.—The palm oils received at the Imperial Institute were typical of those produced in the Eastern Province, and are described in Mr. Farquhar's report as follows:—

1. Bad quality; rancid, with a bad smell and with dark and green patches; bought as a "soft" oil at Calabar.
2. Bad quality, "mixed" oil, bought at Calabar.
3. Bad quality, "mixed" oil, bought as a "soft" oil.
4. Oil bought as "soft" oil at Calabar.
5. Oil bought as "hard" oil at Calabar.
6. Oil bought as "mixed" oil at Calabar.
7. Fresh oil from Ahoada district.
8. Best quality "soft" oil; Eket Opobo.

9. Oil bought as "soft" oil, Oron.

All the samples had the usual colour and appearance of palm oil, and it is therefore unnecessary to describe them in detail. The samples measured about one pint in each case.

It was specially desired to know how these oils would be classified commercially, and, in view of the number of complete analyses of palm oil from Southern Nigeria already made at the Imperial Institute (see p. 527), the examination was confined to this point in the first instance. The classification of palm oil on the market depends mainly on the condition in which it is received, and the two principal factors are:—

(a) The percentage of impurities, such as dirt and water, present in the consignment.

(b) The "hardness" or "softness" of the oil.

The results of the examination of the samples are given in the following table:—

Number of Sample.	Moisture.	Dirt.	Melting-point of oil.*	Acid value.	Glycerine.	
					Calculated from acid value.	Determined experimentally.
	Per cent.	*Per cent.*	°C.		*Per cent.*	*Per cent*
1	0·55	0·44	38–39°	94·5	6·25	—
2	0·48	0·30	34°	51·6	8·40	—
3	0·80	0·34	34–35°	52·3	8·37	—
4	0·86	0·13	30°	25·4	9·72	—
5	1·10	0·37	34·5°	70·7	7·46	7·2
6	0·94	0·41	36°	72·7	7·37	7·3
7	0·26	0·04	29–30°	11·1	10·45	10·1
8	0·18	0·02	24°	15·6	10·21	—
9	1·05	0·92	39–40°	102·3	5·85	—

* *Approximate determinations by open capillary-tube method.*

It is clear from these results that all nine samples were satisfactory as regards the percentages of dirt and moisture present, and no serious exception could be taken to any of them on this ground.

The acidity determinations showed that three of these oils (Nos. 4, 7, and 8) had undergone only slight fermentation and would be classed as "soft" oils, whilst four others (Nos. 1, 5, 6, and 9) were highly fermented and would be classed as "hard" oils. The remaining specimens, Nos. 2 and 3, would probably be classed as "mixed" oils, since they were intermediate in acidity between the typically "soft" and the typically "hard" oils. The same classification of the nine oils results from a comparison of their melting-points, but the acidity figures give a much clearer indication of the class to which each oil belongs.

The importance of the distinction between "soft," "mixed," and "hard" oils from a commercial point of view lies mainly in the fact that the inferior "mixed" and "hard" oils, owing to their faulty method of preparation, yield, when used for soap manufacture, less of the valuable by-product, glycerine, than do

the "soft" oils, and it is for this reason mainly that they fetch lower prices. The amount of glycerine which can be obtained from an oil or fat can be roughly calculated from the acid value, but as this involves certain assumptions, it was thought desirable in the present instance to check the values thus arrived at by direct determinations of the glycerine in several cases, and the figures obtained in these two ways are given in columns 6 and 7 of the above table.

It is understood that some difficulty has been experienced recently by importers of palm oil owing to the fact that certain West African ports which formerly shipped only "soft" oil have begun to ship "mixed" or "semi-hard" oils.

Mr. Farquhar refers to this matter in connection with shipments of palm oil from Calabar, and explains that this is due to the fact that in recent years the upper reaches of the Cross River have been opened up, and from thence palm oil, prepared in various ways, now reaches Calabar for shipment. Much of the oil from this area appears to be "hard" or "semi-hard," whereas formerly all the oil shipped from Calabar was "soft." There is no satisfactory simple test by which "soft" and "hard" or "semi-hard" oils may be distinguished in the course of actual trading operations in West Africa, and consequently oil purchased as "soft" oil has in some cases turned out to be inferior "hard" oil when examined in Europe. Examples of this are shown in the series of oils dealt with in this report (p. 529). The remedy seems to lie in encouraging the natives to abandon the fermentation process of extracting palm oil, but unfortunately when fresh fruits are employed the process of extraction is more expensive, as it entails the use of large boiling-pots and the consumption of a good deal of fuel, and these are serious difficulties to the natives in some areas.

Palm Fruit.—A sample of palm fruit known to the Efik people as "Ayara Mbana" was received from Calabar in March 1912. The fruits were large, pale brownish-yellow in colour, and of irregular shape. They differed from ordinary palm fruits in being almost enclosed in a thick, oily perianth; as a rule the perianth of the mature fruit, although enveloping the fruit in a similar manner, is dry and scarious. The shells of the nuts were moderately thick and the kernels rather small.

The average weight of the fruits, nuts, and kernels was approximately 8·9, 3·75, and 1·13 grams respectively. The perianth constituted 21·3 per cent. of the fruit by weight, the pulp 35·8 per cent., and the nuts 42·9 per cent. The pulp contained 8·9 per cent. moisture and 76·1 per cent. oil, equivalent to 27·2 per cent. expressed on the whole fruit and 83·5 per cent. expressed on the dry pulp. The nuts consisted of 70 per cent. shell and 30 per cent. kernel, the latter containing 20·1 per cent. moisture and 43·4 per cent. oil, equivalent to 54·3 per cent. calculated on the dry kernel. The perianth contained 10·6 per cent. moisture and 69·9 per cent. oil, equivalent to 14·8 per cent. expressed on the whole fruit and 78·2 per cent. expressed on the dry perianth.

It will be seen that the fruits as received contained 42 per cent. of palm oil, viz. 14·8 per cent. in the outer pulpy covering (perianth) and 27·2 per cent. in the ordinary pulp adhering to the nuts.

This yield is almost as large as that given by the "Abobo-be" palm fruit of the Gold Coast or the "A-sog-e-jub" variety of Southern Nigeria (see pp. 517, 525). The yield of kernels in the present instance is, however, low, being only 12·9 per cent. expressed on the fruits as received.

A variety of palm fruit similar to that under report has been recorded under the name of "Klude" as occurring in the Misahöhe district of Togoland (see *Der Tropenflanzer*, 1904, **8**, 283). The fruit does not appear, however, to have been described as a distinct botanical variety, and it seems not unlikely that it is merely a "sport."

It would be of much interest if the seed of this palm could be grown experimentally in Southern Nigeria, in order to ascertain whether the offspring would produce the characteristic fruits of the parent plant.

The exports of palm oil and palm kernels from Southern Nigeria in recent years are shown in the following table; for the sake of uniformity the quantities of palm oil exported in 1907-09 have been converted from gallons to tons, 243·5 gallons being taken as weighing 1 ton.

—	1907.		1908.	
Palm oil	Tons. 75,288	£ 1,313,960	Tons. 75,273	£ 1,154,933
Palm kernels	Tons. 133,630	£ 1,658,292	Tons. 136,558	£ 1,424,595

—	1909.		1910.		1911.	
Palm oil ...	Tons. 94,441	£ 1,447,163	Tons. 76,850	£ 1,742,234	Tons. 79,337	£ 1,696,876
Palm kernels..	Tons. 158,849	£ 1,815,967	Tons. 172,997	£ 2,450,815	Tons. 176,389	£ 2,574,405

Uganda.

A consignment of palm fruits of irregular size and shape, having a thin pulp enclosing thick-shelled nuts, was received from Uganda in October, 1909. The pulp was very dry, and had mostly been rubbed off in transit. The dimensions and weight of the fruits, etc., were as follows:

—	Fruits.	Nuts.	Kernels.
Length, *inches*...	1·3 to 2·0	1·0 to 1·75	0·6 to 0·85
Diameter, *inches*	0·7 to 1·55	0·65 to 1·2	0·4 to 0·6
Thickness of shell, *inches* ...	—	0·1 to 0·35	—
Weight, *grams*	—	3 to 16	0·5 to 2·5

The nuts consisted of 83 per cent. shell and 17 per cent. kernel,

of oil, equivalent to 50·4 per cent. in the dry kernel. The weight of the fruits, the percentages of pulp and nut, and the amount of moisture and oil in the pulp could not be determined, owing to the damaged state of the fruits.

The fruits were received in poor condition, but they evidently belonged to the poorest class of oil-palm fruits, having a thin pulp and thick-shelled nuts, and resembled in type such varieties as the "Abe-pa" and "Abe-dam" from the Gold Coast and "Udin" from Southern Nigeria.

NYASALAND.

A sample of palm fruits from the north end of Lake Nyasa, where a limited number of palms occur, was received in March, 1909. The fruits were large, usually with thick-shelled nuts and thin pulp, but two of the fruits examined contained typical thin-shelled nuts. The average dimensions and weight of the fruits, etc., were as follows:—

——	Fruits.	Nuts.	Kernels.
Length, *inches*	1·4	1·0	0·6
Diameter, *inches*	1·0	0·7	0·4
Thickness of shell, *inches* ...	—	0·15	—
Weight, *grams*	12·0	6·2	1·1

The fruits consisted of 49 per cent. pulp and 51 per cent. nuts, the percentage of kernels being 8·6. The pulp contained 3·4 per cent. of moisture and 76·9 per cent. of oil, equivalent to 37·6 per cent. in the whole fruit and 79·6 per cent. in the dry pulp. The nuts consisted of 83 per cent. shell and 17 per cent. kernel; the latter containing 6·8 per cent. of moisture and 48·1 per cent. of oil, equivalent to 51·5 per cent. in the dry kernel.

These Nyasaland palm fruits, like those from Uganda, belonged to the class having a thin pulp and a thick-shelled nut, typically represented by such fruits as the "Abe-pa" and "Abe-dam" of the Gold Coast or the "Udin" of Southern Nigeria. These varieties, however, give smaller yields of palm oil, as a rule, than the Nyasaland fruits. It is of interest to note that two fruits in the present sample had thin-shelled nuts, resembling in this respect the "Abobo-be" variety of the Gold Coast, so that possibly oil palms of this class also occur in small quantity in Nyasaland.

It is understood that the oil palm does not occur in sufficient quantity in Nyasaland to make the extraction of palm oil or palm kernels of commercial interest in the Protectorate. The results now recorded, however, indicate the class of oil palm which occurs in the country.

MOZAMBIQUE.

The oil palm is at present only cultivated on a small scale in the Mozambique Company's Territory in Portuguese East Africa, and supplies are not yet available in large quantities. Two samples of palm nuts from this country have been examined at the Imperial Institute.

The first sample consisted of dry nuts, many of which were covered with dried pulp. The nuts were large and of the ordinary thick-shelled variety, the average dimensions and weight being as follows:—

	Nuts.	Kernels.
Length, inches	1·1	0·65
Diameter, inches	0·8	0·50
Thickness of shell, inches	0·15	—
Weight, grams	6·7	1·6

The nuts consisted of shell 77 per cent. and kernel 23 per cent. The kernels contained 5·5 per cent. of moisture and 50·5 per cent. of oil of normal character, equivalent to 53·4 per cent. in the dry kernel, and were similar in all respects to ordinary commercial samples of palm kernels. If freed from shell and in good condition the kernels would probably realise the current market price of palm kernels.

The second sample closely resembled the first, but gave a rather lower yield of kernels, viz. 19·6 per cent. The approximate average weight of the nuts was 9·3 grams, and of the kernels 1·8 grams.

General Conclusions.

Reference was made at p. 510 to the fact that the investigations which have led to the results now recorded were initiated with a view to ascertaining the precise position of the palm-oil industry in British West Africa, and the possibility of introducing more modern methods of exploiting the oil-palm forests. The principal points ascertained may be summarised thus:—

1. There is an abundant supply of palm fruits, and large areas of oil-palm forest still exist almost untouched. There is consequently no fear in the immediate future of a failure in the supply of palm oil and palm kernels even if the crude and wasteful native processes of exploitation are persisted in.
2. Palm oil and palm kernels are still extracted mainly by native methods, and the machinery now available for these purposes seems to have been adopted on a very small scale only, as far as British West Africa is concerned.*
3. Several varieties of oil palm occur in most of the British West African Colonies which produce palm oil, and of these the varieties yielding thin-shelled nuts present distinct advantages, in higher yields of palm oil and in some cases of palm kernels, over those yielding thick-shelled nuts.

There are two directions in which improvement of the palm-oil industry may be looked for in the future, viz. the introduc-

* Since the date of this report (February, 1910) considerable progress has been made in the introduction of machinery for extracting palm oil and kernels.

tion of machinery for the extraction of palm oil and palm kernels, and the gradual replacement of the ordinary oil palm by varieties giving higher yields of palm oil and kernels.

Introduction of machinery.—Most of the machinery so far introduced is too expensive for use by natives, and so long as the industry remains in native hands it is unlikely that machinery will be largely introduced. The natural remedy for this state of things, so far as British West Africa is concerned, would appear to be the installation of central palm-oil factories under either Government or private European control.* The actual collection of the palm fruits would still be carried on by natives, who should be encouraged to sell the fruits to the central factory in their district. This system of central factories has been found to work well for ginning cotton in West Africa, and experiments are in progress for its adoption for cocoa fermentation in the Gold Coast. The same plan has been found to answer well in other countries for such products as tobacco, sugar beet, sugar cane, coarse textile fibres and other materials. The principal difference between the products so far dealt with in this manner and palm fruits is that the former are agricultural materials while the latter is a forest product. In the case of agricultural materials it can generally be arranged that these will be grown in the neighbourhood of the central factory, and the site of the latter is selected with that end in view. This is not so easy to arrange as a rule in the case of forest products, but as regards palm oil the trees yielding it occur in dense masses over large areas, and it should be easy so to place central factories as to avoid transport of the collected palm fruits over considerable distances. With the development of good roads suitable for wheeled transport and the extension of railways this method of working would be rendered still easier. The advantages of such a system would be a great saving in labour, the avoidance of waste such as goes on in the native manufacture of palm oil, and lastly the preparation of a much better quality of palm oil than is at present put on the market.

In such colonies as Sierra Leone, where the cost of labour is relatively high, the introduction of machinery would obviate a serious obstacle to the extension of palm oil production.

The gradual replacement of the common oil palm by better varieties.—This matter presents great difficulties. In the first place there are enormous areas of oil palms still untouched, and in the areas at present worked large quantities of palm fruits are left ungathered. From the point of view even of increased production there is therefore no need to form plantations. At the same time, as has been indicated already, a certain amount of re-planting is done by natives in a haphazard fashion, and there seems to be no reason why this re-planting should not be done with the best kinds. It is, however, not at all easy to decide which are the best varieties. The "Abobo-be" of the Gold Coast and the "A-sog-e-jub" of the Central Province of Southern Nigeria have been shown in the present investigation to give high yields

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* This proposal has been carried into effect by several European firms in West Africa.

of oil and a good yield of thin-shelled nuts, which can be easily shelled. It should be noted, however, that the kernels from thin-shelled nuts are, as a rule smaller than from thick-shelled nuts, so that to get the same yield of kernels more nuts have to be cracked. The saving in labour may not in practice prove, therefore, to be quite so large as has been generally supposed. The "seedless" kind of the Gold Coast is, as Dr. Soskin points out, almost ideal as a source of palm oil, since it merely requires pressing in an ordinary oil-press to give a far higher yield of palm oil than is obtainable from any other palm fruit.*

These varieties cannot, however, be recommended yet for general planting for the following reasons: It is not at all certain that they can be raised true to seed in a new district, and the small experiment made with Lisombé nuts at the Victoria Gardens in Kamerun to some extent supports this view. Further, it is not known what the yield of these good varieties is in comparison with the ordinary oil palm. It is quite possible that they come into bearing later and give a smaller yield of "heads" of fruit. These and other points must be settled by experimental plantations before any recommendations can be safely made regarding the encouragement of these kinds for re-planting in preference to the ordinary oil palm. It would seem to be advisable therefore, to form experimental plantations of these kinds at a number of places in each colony, and more especially in Southern Nigeria, Sierra Leone and the Gold Coast Colony, so that data may be obtained (1) as to the possibility of raising these varieties of oil palm *without deterioration* in new localities, and (2) as to their actual value in yield per acre of palm oil and kernels. In all cases similar plantations of the ordinary oil palm should be formed in the same districts, so that strictly comparable information regarding these may be obtained. In such plantations experiments in crossing varieties might also be carried out. Between the rows of oil palms maize might be grown as a catch crop as suggested by Adam.

The Inspector of Agriculture for West Africa has suggested that such plantations of oil palms might be formed and separated from each other by plantations of *Funtumia elastica*, the latter being utilised for the carrying out of tapping and other experiments, which are much needed. This plan would have the obvious advantage of enabling series of observations to be carried out on two very important West African industries with the minimum expense for the necessary European supervision. The plantations would have the further advantage of serving to educate natives in two important branches of planting work, and with this end in view the plantations should be worked on modern lines, palm oil and palm kernels being extracted by machinery, and the refuse being returned to the plantations as manure. Similarly the rubber plantations could be utilised for instructing natives in methods of tapping trees and preparing rubber.

* Farquhar has suggested recently (*loc. cit.*) that the so-called seedless varieties may be merely incompletely developed palm fruits.

COPRA.

Gold Coast.

Two samples of copra were forwarded from Accra in September, 1910.

One sample consisted of fair-sized pieces of dirty copra, apparently prepared from small nuts.

The second sample was also very dirty, and in smaller pieces than sample No. 1. The material had an unpleasant smell and was in poor condition.

The samples yielded respectively 65·7 and 66·6 per cent. of oil, which are normal yields for well-dried copra.

The materials were submitted to brokers, who reported that both samples were of poor quality. They valued No. 1 at £18 17s. 6d. to £19 per ton, and No. 2 at probably £5 less, with copra from the Straits Settlements at £23 10s. per ton (December, 1910). They added that if proper attention were given to the preparation of African copra it would realise a much higher price than at present.

The inferior quality of these samples appears to have been caused by lack of care in drying the material. It seems probable that the copra was allowed to get wet during the course of preparation and, in consequence, its commercial value was considerably decreased.

Northern Nigeria.

This sample was received in June, 1911.

It was labelled "Copra prepared from coconuts gathered at Aiere, near Kabba," and consisted of pieces of coconut shell with portions of the kernel still adhering more or less firmly to them. The portions of the kernel were somewhat mouldy.

The kernel detached from the shell yielded 67·0 per cent. of oil and contained 4·3 per cent. of moisture. The oil possessed the usual characters of coconut oil and was not submitted to detailed examination.

The present sample was not copra in the commercial sense, and it was not submitted to brokers for valuation. The results of the examination show, however, that copra of good and readily saleable quality could be prepared from the coconuts which furnished this material.

Southern Nigeria.

This sample of copra was received in March, 1910.

It weighed $5\frac{1}{4}$ lb. and consisted of shelled coconuts, cut in half and dried. It was in very good condition, the inner surfaces of the nuts being only slightly brown and quite free from mould. The material was not rancid in odour or taste. As the copra was normal and obviously of good quality no analysis was made.

The material was submitted for valuation to soap manufacturers and to brokers. The manufacturers reported that the copra was quite equal in appearance to the best grades of Ceylon produce, but that the oil obtained from it, whilst of good colour and odour, contained a higher percentage of free acids than Ceylon oil. The

manufacturers added that there is not the slightest doubt that if copra can be supplied from Southern Nigeria in the condition of this sample it will find a ready market at high prices.

The brokers described the copra as a very good sample, and stated that there would be a good sale for it in this country.

The best qualities of copra were quoted on the London market on the same date (July, 1910), as follows:—

- Australian sun-dried, £21 10s. to £21 12s. 6d. per ton.
- Singapore, £22 7s. 6d. to £22 10s. per ton.
- Federated Malay States, £23 per ton.
- Ceylon, £26 17s. 6d. per ton.
- Zanzibar, £22 5s. per ton.
- Manila, £22 10s. per ton.

African copra was quoted in Liverpool at £18 10s. per ton for fine quality material on the same date.

COCONUT OIL.

SOUTHERN NIGERIA.

This sample was forwarded to the Imperial Institute from Calabar in January, 1910. It consisted of a white, solid, crystalline fat, having the characteristic odour of coconut oil; a small quantity of vegetable impurity was present. On melting the fat a faint "burnt" smell became apparent. On analysis the following results were obtained:—

	Present sample.	Commercial coconut oil (Lewkowitsch).
Specific gravity at 100° C./15·5° C. ...	0·870	0·874
Acid value	0·5	—
Saponification value	262·0	246·0 to 268·4
Iodine value	7·0	8·0 to 9·3[illegible]

The pure white colour and low acid value of this sample showed that it was carefully prepared. The small amount of impurity present could be removed by straining the melted oil. Care should however be taken not to overheat the oil, as this tends to produce the "burnt" smell noticed in the present instance.

Coconut oil of the quality of this sample would, if quite clean be readily saleable at the current market price, which varied between £42 10s. and £45 per ton at the date of report (April 1910).

CEYLON AND WEST INDIES.

Two samples of coconut oil were forwarded to the Imperial Institute by the Imperial Commissioner of Agriculture for the West Indies in December, 1904, in order that their value as preventives of fouling in rifles might be determined in comparison with that of the oil specially issued for this purpose by the Army authorities.

The two samples of coconut oil, one labelled "from Trinidad" and the other "from Ceylon," were practically identical in appearance, taste and odour. They were submitted to chemical examination and furnished the following results:—

	Coconut oil from Ceylon.	Coconut oil from Trinidad.
Specific gravity at 100°/15·5° C. ...	0·8787	0·8702
Melting-point	26° C.	24·5–25·5° C.
Free fatty acids (calculated as oleic), per cent.	3·35	4·85
Saponification value	260	262
Iodine value	9·0	8·2
Hehner value	85·6	85·9
Reichert-Meissl value	7·15	7·26

These figures, which agree well with the recorded constants of coconut oil, show that the two samples are practically identical in composition, the only notable difference being that the sample from Trinidad contains more free fatty acid than that from Ceylon and might on that account be considered rather less suitable for the purpose indicated.

In these circumstances it seemed desirable to institute practical trials with the two samples of coconut oil, and, with the consent of the Chief Superintendent of Ordnance Factories, a number of tests have been made at the Royal Small Arms Factory at Enfield for the purpose of comparing the samples with each other and with the service rifle oil. The report furnished by the Superintendent of the Small Arms Factory upon the results of these tests states that the two samples of coconut oil gave identical results when applied to rifle barrels in order to prevent fouling. With reference to the value of the coconut oils compared with the service rifle oil, he reports as follows: "It is found that, as a protective coating for a short period, the coconut oil shows to slight advantage as compared with the rifle oil—more especially when applied to the surface of the barrel after that surface has been thoroughly cleaned with hot soda and water and dried. When, however, the barrel was not cleaned out with soda and water after firing, and was then treated with the competing oils, the coconut oil appeared somewhat better at the end of the first seven days of keeping; but, after 14 days, the rifles treated with service rifle oil were in the better condition, and after a month a large amount of fouling had appeared in the barrels treated with the coconut oil, whilst those treated with the service rifle oil remained bright and clean. It therefore appears clear that this oil is inferior for the purpose of preserving rifle barrels to the service rifle oil."

"SHEA" NUTS AND BUTTER.

A considerable amount of attention has been given to "Shea butter" in recent years as a raw material for the manufacture of soap and candles, and also for the production of edible fats; and, as a result, interest in the possibility of increasing trade in this product has been aroused, particularly in West Africa, whence the commercial supply of the "nuts" and butter is derived at present.

The following table shows the exports of Shea nuts and Shea butter from Southern Nigeria in recent years:—

—	1909.		1910.		1911.	
	Tons.	£	Tons.	£	Tons.	£
Shea nuts	9,728	78,029	4,464	43,510	3,629	35,518
Shea butter	309	5,230	340	6,804	248	4,978

The specimens of these products now dealt with have been received from the Governments of Northern and Southern Nigeria, the Gold Coast, the Sudan, Uganda, and in part from the Niger Company.

SOUTHERN NIGERIA.

Shea Butter.—This was received from Lagos in July, 1905, and consisted of two packages of Shea butter, each weighing about 21 lb. The butter was soft, of pale greenish-yellow colour, and possessed a slight characteristic odour.

Shea Nuts.—Two samples were received in October, 1905, and two in January, 1906.

(1) One of these was labelled "Tengba," and consisted of 50 lb. of small, nearly black seed-kernels many of which were pierced by insects.

(2) The second was labelled "Bomo," and consisted of 50 lb. of small, dark brown seed-kernels.

(3) A third sample consisted of large kernels, which varied in colour from light to dark brown. Many of the kernels had been attacked by insects.

(4) A fourth was described as "kiln-dried Shea nuts," and consisted of small light brown kernels, only a few of which had been attacked by insects. The last two samples represented the material as usually imported into this country.

The percentages of fat in the four samples of kernels were determined by extraction with light petroleum, with the following results:—

No. of Sample.	Percentage of fat in the kernels.
1	54·5
2	48·0
3	41·4
4	46·2

The sample of Shea butter forwarded from Lagos, and the fats extracted from samples of nuts Nos. 3 and 4 referred to above, were examined chemically. It was thought that a comparison of the two latter specimens would indicate whether the kiln-drying had affected the chemical composition of the fat. The results are given in the following table:—

—	Shea butter from Lagos.	Fat from untreated kernels No. 3.	Fat from kiln-dried nuts No. 4.
Specific gravity at $\frac{100° C.}{15 \cdot 5° C.}$	0·862	—	—
Acid value	18·0	33·9	26·2
Saponification value	179·0	181·2	180·2
Iodine value	58·7	59·4	55·6
Hehner value	96·5	—	—
Unsaponifiable matter ...	1·7	—	—
Titer test	52·0°C.	—	—

It will be seen that these results are in general agreement, the only considerable difference being in the acid values.

A comparison of the figures for the fats extracted here, shows that the kiln-dried kernels contain a lower percentage of free fatty acids than the other specimen.

NORTHERN NIGERIA.

Early in 1908 two specimens of nuts, labelled "Giddauchi" and "Eko" respectively, were received from Northern Nigeria. These were identified at Kew as seeds of "forms" of *Butyrospermum Parkii* (the Shea butter tree). The seeds presented considerable difference in size, the "Eko" sort ranging from 1·5 to 2·5 inches in length, whilst the "Giddauchi" variety was about 1·4 inches long on the average. These differences are of some interest in view of Chevalier's recognition (see *Bulletin of the Imperial Institute*, 1908, **6**, 449) of several varieties of the Shea butter tree. The results of the examination of the two kinds are as follows:—

	Giddauchi nuts.	Eko nuts.
Kernels: Yield of fat, per cent.	48·6	52·4
Fat: Specific gravity at $\frac{99° C.}{15° C.}$	0·8691	0·8671
Acid value	7·6	18·2
Saponification value	181·5	182·8
Iodine value	62·0	57·7
Hehner value	91·2	94·6
Reichert-Meissl value	2·6	1·84
Unsaponifiable matter	6·3	7·0

The principal difference to be noted is in the higher proportion of unsaponifiable matter in the fats from these kernels received direct from Northern Nigeria than in those obtained from kernels as imported from Southern Nigeria and in the native-prepared Shea butter. It is stated, however, that in commercial samples of Shea butter and Shea oil (the product expressed from the kernels in Europe) as much as 10 per cent. of unsaponifiable matter sometimes occurs.

GOLD COAST.

Shea nuts.—This sample, labelled "Shea nuts prepared by natives of the Northern Territories," was received in September, 1911, and consisted of clean, rather small Shea kernels, in good condition.

It yielded on extraction 51·2 per cent. of fat as compared with 46·2 to 54·5 per cent. in the case of previous samples examined at the Imperial Institute. The fat had the usual characters of Shea butter.

These Shea kernels should realise the current market price, viz., £10 10*s*. per ton in Liverpool (March, 1912).

Shea butter.—This sample, labelled "Shea butter prepared by natives of the Northern Territories," was receive in September, 1911. It consisted of solid, greyish, cream-coloured fat, with a pleasant odour and apparently free from dirt. A small amount of colourless insoluble matter was present, and was removed by filtration of the melted fat before analysis.

The following results were obtained:—

	Present sample.	Previous samples examined at the Imperial Institute.
Specific gravity at 100°/15·5° C.	0·864	0·859 to 0·869
Acid value	5·3	7·6 to 33·9
Saponification value	183	179 to 184·6
Iodine value	58·7	56 to 63

This Shea butter resembled previous samples examined at the Imperial Institute, but had a slightly lower acid value, probably owing to more careful preparation. Similar fat would be readily saleable in Europe at the current rates, viz., £28 5*s*. per ton in Liverpool (March, 1912).

SUDAN.

In the Sudan the nuts and butter are known as "Lulu" nuts and oil. Samples of the oil and nuts were received in May, 1906, and October, 1907, respectively.

Lulu Nuts.—These were smaller and rounder than those received from West Africa, but otherwise were similar in appearance. The proportion of shell to kernel was approximately as 1 : 2.

The kernels yielded 47·2 per cent. of very pale yellow fat, as compared with 46·4 to 52·4 per cent. of fat obtained from the Nigerian samples. On examination this gave the following results:—

Specific gravity at $\frac{99° C.}{15° C.}$	0·8594
Saponification value	184·0
Iodine value	62·9
Hehner value	91·9
Reichert-Meissl value	1·4
Unsaponifiable matter	4·3

Lulu Oil.—This consisted of the solid fat, which had a dull, greyish colour, quite different from the pale yellow colour of the West African product. On melting and filtering, a considerable quantity of suspended matter was found to be present, but the filtered "butter" still retained its original colour, and appeared to be rather softer than the samples of Shea butter from West Africa, which have been examined at the Imperial Institute. From the appearance and smell of the specimen it seemed possible that the fat had been overheated in the process of extraction from the seeds.

The fat was submitted to chemical examination, and the results obtained are given in the following table:—

Acid value	10·7
Saponification value	184·6
Iodine value	56·0
Titer test	51·8° C.

The constants found for this sample of "Lulu oil" from the Bahr-el-Ghazal are in general agreement with those obtained at the Imperial Institute for samples of Shea butter from other sources, and also with the results recorded by Dr. Beam for two other Sudanese specimens.

The dull greyish colour of this sample of "Lulu oil" from the Sudan might possibly create a prejudice against it, but this defect could probably be easily overcome by more careful preparation.

Shea butter is used in the manufacture of candles, and also to some extent in soap-making, although the large amount of unsaponifiable matter, which it sometimes contains, is said to render it unsatisfactory for the latter purpose. The high percentage of free fatty acids renders the fat unsuitable for lubricating purposes.

Refined Shea butter is said to have been employed recently, especially on the Continent, for use in the manufacture of butter substitutes, and for other edible products, but it is difficult to obtain definite information on this point. An analysis made at the Imperial Institute of one of these products indicated that Shea butter was at least an important component. Its application for these purposes should render it possible to obtain a higher price for the fat than soap and candle makers could offer.

A sample of the Shea butter from Lagos was submitted to a firm of brokers in Liverpool, who reported it to be of the same quality as that usually received from the Niger. The value of Shea butter for candle- and soap-making is usually about the same as that of soft palm oil, such as Bonny or Calabar, the price of which at the date of the report (November, 1907) was £24 5*s.* to £24 10*s.* per ton. The brokers stated that there is a fair demand for Shea butter, and consignments are readily saleable.

UGANDA.

Shea Kernels.—This sample, labelled "Kernels of *Butyrospermum Parkii,*" was received in October, 1911. The kernels were in good condition and had the usual appearance of Shea nut kernels.

The sample yielded 49·9 per cent. of solid, creamy yellow fat. Previous samples of Shea nut kernels examined at the Imperial Institute have yielded from 46·2 to 54·5 per cent. of fat.

These Shea nut kernels, if exported from Uganda to the United Kingdom in good dry condition, would fetch the current market rate, viz., £10 10s. per ton in Liverpool (February, 1912).

SEEDS OF *MIMUSOPS* SP.

SOUTHERN NIGERIA.

This product is of interest, since the nuts closely resemble Shea nuts in appearance but are usually somewhat larger. The botanical name of the plant is not known with certainty, but from the specimens sent to Kew, it appears to be a species of *Mimusops*, probably *Mimusops Djave*, the seeds of which are known to yield a similar fat (*Rev. Fett. Harz. Ind.*, 1908, **15**, 78 and 106).

The sample examined was received in 1906, and consisted of nuts of light brown colour, about 2 inches long and 1 $1\frac{1}{2}$ inches in diameter, with blunt-pointed ends. The shells were smooth, hard and shiny, except on one side, which bore a rough broad scar running from end to end; they were easily broken and separated from the kernel. The latter varied in colour from cream to brown, possessed a curious fruity odour and an unpleasant, bitter taste. The kernels formed 62·7 per cent. by weight of the whole nuts.

The yield of fat on extraction by solvents was 60·2 per cent. from the kernels, corresponding to 37·7 per cent. from the whole nuts. The fat was solid at the ordinary temperature, nearly white, and resembled Shea butter. It gradually developed a slightly rancid odour on exposure to the air. On examination it gave the following results:—

Specific gravity at $\frac{100^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$	0·860
Acid value	25·3
Saponification value	187·6
Iodine value	56·2
Hehner value	95·4
Reichert-Meissl value	nil.
Unsaponifiable matter	2·6 approx.
Titer test	47·8° C.

The kernels would probably be of about the same value as Shea kernels (see above). The "constants" of the fat correspond closely with those of Shea butter.

BACO OR ABAKU NUTS.

(*Dumoria Heckeli*, A. Chev.)

GOLD COAST.

This sample was received in 1909. It was labelled "Baco (Abaku) nuts" and consisted of large, pale brown nuts with

thick, hard, woody shells. The kernels were in most cases mouldy. The nuts consisted of shell 65, and kernel 35 per cent.

The kernels contained 60·5 per cent. of fat, corresponding to 21 per cent. from the whole nuts.

The fat was solid and of a creamy white colour, resembling that from the *Mimusops* nuts from Southern Nigeria (see above).

Specific gravity at 100°/15·5° C.	0·855
Acid value	34·7
Saponification value	188·4
Iodine value	51·3
Titer test	51·2° C.
Unsaponifiable matter	1·3

A firm of soap-makers, to whom these nuts were submitted, reported that the fat would be of about the same value for soap-making as middling quality palm oil. The kernels have an intensely bitter taste, so that the cake left after the extraction of the fat would not be suitable for use as a feeding-stuff. Since the kernels appear to become mouldy when left in the shells and as the latter would be of no value except for fuel, the nuts should be shelled locally and the kernels dried before shipment. The firm added that the dried kernels, in good condition, would be worth about £13 per ton in England (February, 1910).

BASSIA KERNELS AND FATS.

In the last few years there has been a remarkable rise in the prices of almost all oil-seeds, oils and fats. This is to be attributed in part to the increase in the demand for oils and fats for edible purposes, principally as salad and cooking oils, butter substitutes, chocolate fats and cooking fats.

One of the most promising sources of hard vegetable fat for edible purposes is the seeds of the various species of Bassia (N.O. Sapotaceæ) occurring commonly throughout the East Indies, and already imported into Europe under the name of "mowra" seeds. Seeds of *Bassia* spp. appear also to come on the market as "illipe seeds," but this name is undoubtedly also now applied in commerce to seeds derived from genera other than Bassia. There is a good deal of confusion as to the botanical origin of the seeds known commercially by these names, and the Imperial Institute has endeavoured to obtain for examination authentic samples from India, Ceylon, Borneo and elsewhere, of the Bassia and other Sapotaceous seeds which come into commerce, with a view to obtaining definite information as to the relative values of the kernels of the different species as sources of fat. These enquiries are not yet completed, but as a considerable amount of information has been accumulated it seems worth while to place this on record.

For a detailed account of the chemistry of the Bassia fats see "The Composition of Bassia Fats," by R. G. Pelly (*Journ. Soc. Chem. Ind.*, 1912, **31**, 98).

INDIA.

The materials received from India have included specimens of the fruits, seeds, kernels and fats of *Bassia latifolia*, *B. longifolia* and *B. butyracea*. According to Sir George Watt (*The Commercial Products of India*, London, 1908, p. 116) *Bassia latifolia* is generally known in India under the vernacular names "mahua," "mahwa" or "mowha," but is also known in some parts as "illupei" or "illupai," the former being Hindustani and the latter Tamil names. The same names are also applied to *Bassia longifolia* in India, but since this species occurs only in Southern India it is more commonly called by its Tamil names "illupei" or "illipi." It is not safe to assume therefore, as is done by some authorities, that the "mowra" or "mahua" seeds of India are derived from *B. latifolia* and the "illipi" seeds from *B. longifolia*, though this is doubtless generally true. *Bassia butyracea* is known in India as "phulwara," and the solid fat obtained from the seeds is called "phulwa." *Bassia latifolia* occurs in the forests of the central tracts of India, from Western Bengal, Oudh and Kumaun to Gujarat, Kanara and Burma, up to altitudes of 4,000 feet, and is often cultivated. In Southern India it is replaced by *B. longifolia* from Konkan southwards. *Bassia butyracea* occurs in the Sub-Himalayan tracts, from the Ganges to Bhutan, and ascends to altitudes of 15,000 feet. Considerable quantities of fat are expressed in India from the kernels of all three species, and are eaten either as such or are used to adulterate "ghi."

According to the Indian trade returns, "mowra" seeds have been exported in the following quantities and values in recent years:—

—	1907–08.	1908–09.	1909–10.	1910–11.
Cwts.	795,196	407,272	784,037	415,662
Rupees*	44,56,383	24,92,415	46,71,329	31,10,352

* 1 *rupee* = 1*s.* 4*d.*

Bassia latifolia.

No. 1. "*Bassia latifolia* seed from Nagpur, Central Provinces." The sample consisted of hard, pale reddish-brown half-kernels, which had evidently been dried. The kernels yielded 46·0 per cent. of soft, pale yellow fat.

No. 2. "*Bassia latifolia* fat from the Central Provinces." This consisted of dirty olive-green fat, possessing an unpleasant odour and containing a large quantity of dirt. After filtering, the fat was orange-yellow in colour and of soft consistence.

No. 3. "*Bassia latifolia* fruits from the Central Provinces." The sample consisted of fruits and seeds in the proportion of 2 to 1. The fruits were brownish-black, oval, about ⅞ inch long, and had hard, thin pericarps. Each fruit contained from 1 to 3 seeds, which had thin, shiny, loosely-fitting husks of brown or

yellow colour. The kernels were chocolate-brown, and in most cases were covered with a dust-like yellow fungus.

The fruits, which weighed about nine to the ounce, consisted on the average of 48 per cent. pericarp and 52 per cent. seed. The kernels formed 71·6 per cent. of the weight of the seeds, and contained 33 per cent. of fat, equivalent to a yield of 23·6 per cent. on the whole seeds, or 12·2 per cent. on the fruits. This yield of 33 per cent. from the kernels is unusually low, possibly because the seeds were immature.

The fat extracted from the kernels by light petroleum was yellow, soft at ordinary temperatures, and had a pleasant taste and odour.

The results of examination of the fat of *B. latifolia* are shown in the following table, together with results obtained by previous observers :—

—	Fat from Sample No. 1.	Sample of fat No. 2. Prepared in India	Fat from Sample No. 3.	Results recorded previously for fat prepared in India (Crossley and Le Sueur).
Specific gravity at $\frac{100° C.}{15·5° C.}$	0·857	0·870	0·862	0·894 to 0·898*
Acid value	—	20·0	(See text below.)	4·8 to 70·8
Saponification value ...	189·8	194·4	188·3	187·4 to 194·0
Iodine value	57·6	76·8	61·5	53·4 to 67·85
Hehner value	94·2	86·7	96·4	94·7 to 95·0
Reichert-Meissl value ...	0·2	1·0	0·9	0·44 to 0·88
Unsaponifiable matter ...	2·0	1·7	—	—
Titer test	43·2°C.	36°C.	46°C.	—

* *Determined at* 100/100° *C.*

The fat extracted from the seeds enclosed in the fruits of sample No. 3 had an acid value of 31·8, whereas that extracted from the loose seeds in the sample had an acid value of 41·8.

From the high iodine value and low titer test of the fat prepared in India (sample No. 2), it seems possible that only the more liquid portion of the fat was extracted, or that possibly oil had been added by the native workers to facilitate the expression of the fat from the ground seed.

The fat of *Bassia latifolia* extracted from the kernels by means of light petroleum was found to contain glycerides of oleic, stearic and probably palmitic acids. From the iodine value of the fat, the glycerides appeared to be present in the following proportions: olein 66 per cent.; stearin and palmitin together, 34 per cent.

It has been stated by Lewkowitsch (*Oils, Fats and Waxes*, London, 1909, Vol. II. 429) that palmitic acid is the chief constituent of the solid acids in *B. latifolia* fat, but in the fat

extracted from sample No. 3 nearly half of the solid fatty acid was stearic acid, which was readily isolated in a pure state.

Bassia longifolia.

No. 1. "*Bassia longifolia* fruits from Taliparamba, Madras." The fruits were blackish in colour and almond-shaped, containing sepia-coloured seeds with brown kernels, many of which were in a powdery condition. The length of the fruits varied from 1·0 to 1·3 inches. The fruit consisted of outer husk 33 per cent; inner husk 20·5 per cent.; kernel 46·5 per cent. The kernels yielded 55·3 per cent. of soft yellow fat.

No. 2. "*Bassia longifolia* fat from Taliparamba, Madras." The sample consisted of dirty yellowish fat, which after filtering was pale yellow in colour.

No. 3. "*Bassia longifolia* kernels from the Palur Agricultural Station, Madras." The sample consisted of brown kernels resembling those contained in the fruits of sample No. 1. The kernels yielded 57·8 per cent. of a soft yellow fat.

The fat of *Bassia longifolia* was examined with the following results; those recorded by previous workers are given for comparison.

—	Fat from Sample No. 1.	Sample of fat No. 2. Prepared in India.	Fat from Sample No. 3.	Results recorded previously (De Negri and Fabris).
Specific gravity at $\frac{100^\circ C.}{15 \cdot 5^\circ C.}$	0·856	0·864	0·861	—
Acid value	—	5·0	19·7	—
Saponification value ...	202·7	198·2	195·3	188·4
Iodine value	54·8	60·0	60·0	50·1
Hehner value	—	87·4	95·5	94·7
Reichert-Meissl value ...	—	3·6	2·35	—
Unsaponifiable matter ...	2·2	2·1	1·4	—
Titer test	—	36° C.	45° C.	39·7° to 40·3° C.

The results of analysis of the fat from sample No. 3 differ somewhat from those for samples Nos. 1 and 2 and from those recorded by previous investigators, including Menon (*Journ. Soc. Chem. Ind.*, 1910, **29**, 1429). It should be pointed out, however, that the fat sent from India (sample No. 2) was dirty and had been badly prepared, whilst that extracted at the Imperial Institute from sample No. 1 was obtained from a specimen of fruits weighing only 10 oz., and can therefore hardly be regarded as representative.

The fat from sample No. 3 was found to contain glycerides of linoleic, oleic, stearic and palmitic acids. The proportions of the glycerides of the unsaturated acids (olein and linolein) an

those of the saturated acids (stearin and palmitin) were about 60 per cent. of the former and 40 per cent. of the latter. The glycerides of oleic and linoleic acids appeared to be present in the proportion of approximately 6 to 1, and the fat would therefore contain about 9 per cent. of linolein.

Bassia butyracea.

No. 1. "*Bassia butyracea* fruits from Kumaun, United Provinces."

No. 2. "*Bassia butyracea* seed from Gonda Division, Eastern Circle, United Provinces."

No. 3. "*Bassia butyracea* seed from Gonda Division, Eastern Circle, United Provinces."

No. 4. "*Bassia butyracea* seed from Kumaun Division, Eastern Circle, United Provinces."

No. 5. "*Bassia butyracea* seed from Kumaun Division, United Provinces."

No. 1 consisted of blackish, oblong fruits, about 1¼ inch in length, with thick, soft, sugary pericarps; they possessed a characteristic sweet smell. Each fruit contained one seed with a brown, shiny, close-fitting husk and a brownish-white kernel.

Nos. 2, 3, 4 and 5 consisted of seeds resembling those contained in the above fruits.

The fruits of No. 1 were composed of pericarp 71·7 per cent. and seed 28·3 per cent. These seeds and those of samples 2, 3 and 5 were found to be constituted as follows:—

Number.	Composition of seed.		Yield of fat.	
	Husk.	Kernel.	On weight of kernel.	On weight of whole seed.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	30	70	60·0	42·0
2	23	77	61·2	47·1
3	31	69	63·1	43·5
5	34	66	66·9	44·2

The fat of *Bassia butyracea* as extracted from samples 1, 2 and 3 at the Imperial Institute was a hard, white solid at ordinary temperatures, and possessed a pleasant taste and smell. That extracted from sample 5 was hard and of pale buff colour.

No. 6. "*Bassia butyracea* fat, Gonda Division, Eastern Circle, United Provinces." The sample consisted of a pale yellow fat containing a large quantity of crushed seed. After filtering, a hard, pale buff coloured fat was obtained.

The results of examination of the fat of *Bassia butyracea* are given in the following table:—

	Fat extracted from sample			Sample No. 6. Fat prepared in India.	Results recorded previously (Crossley & Le Sueur).
	No. 1.	No. 2.	No. 5.		
Specific gravity at $\frac{100°C.}{15.5°C.}$	0·867	0·856	0·857	0·862	0·897*
Acid value	2·6	59·6	—	20·7	16·44
Saponification value ...	197·9	200·0	199·3	195·3	190·8
Iodine value	42·1	39 6	37·6	42·7	42·1
Hehner value	95·7	96·6	—	94·6	94·8
Reichert-Meissl value ...	0·9	nil.	—	4·3	0·44
Unsaponifiable matter ...	—	2·2	2·8	2·8	—
Titer test	50·8°C.	51·5°C.	—	48·2°C.	—

* At 100° C./100° C.

The results obtained at the Imperial Institute agree closely with one another. The saponification values of all four samples are, however, higher than that found by Crossley and Le Sueur, but they agree with that recorded recently by Menon (*loc. cit.*).

The fat of *Bassia butyracea* is somewhat different in character from those of *B. longifolia* and *B. latifolia*, being of lighter colour and harder, and having a higher titer test. It was found to contain glycerides of oleic and palmitic acids, which, calculated from the iodine value of the fat, appeared to be present in the proportion of about 46 per cent. of olein to 54 per cent. of palmitin. The unsaponifiable matter could not be isolated in sufficient quantity for detailed examination. In this and the preceding cases it is semi-crystalline and gives the characteristic reactions of the phytosterols.

CEYLON.

The only species of Bassia represented in the samples from Ceylon is *B. longifolia*, which occurs commonly in the forests of the dry region of the island, but is much rarer, and probably always planted, in the moist low country. *B. latifolia* has been recorded several times for Ceylon, but according to Trimen (*Handbook of the Flora Ceylon*, 1895, Part III, p. 79) *B. longifolia* was without doubt intended.

In Ceylon the plant is known as "Mi" or "Mee" (Sinhalese), but the Tamil name "Illupai" is also employed.

Several samples of the seed and fat were received recently at the Imperial Institute from Ceylon. It was stated that from 15,000 to 20,000 bushels of the seeds could probably be marketed in Ceylon each year, once its value became known to the villagers.

No. 1. This sample, labelled "Mee seed," was in poor condition, the kernels being moist and mostly mouldy. The seeds consisted of 30 per cent. shell and 70 per cent. kernel. The yield of oil was about 39 per cent. from the moist kernels, which contained about 24 per cent. of moisture. After exposure to the air for about a day the kernels contained only 6 to 7 per cent. of moisture and 47 to 48 per cent. of oil, which is a lower percentage than that found for *Bassia longifolia* kernels from India.

The fat was solid and yellowish in colour, having the usual appearance and properties of the fat derived from *Bassia longifolia* kernels. It was not submitted to chemical examination.

No. 2. The sample, labelled "Mee seed, *Bassia longifolia*," was in bad condition, many of the kernels showing signs of decay. Kernels in good condition picked from the sample yielded 54·2 per cent. of fat, which is normal for kernels of this species. The character of the fat was also normal.

No. 3. This sample, labelled "Mee kernels," was in rather bad condition; many of the kernels had been attacked by insects and a quantity of dust and debris was present.

The yield of oil from the kernels was 50·3 per cent., which is somewhat below that given by Indian kernels derived from this species. The character of the fat was normal.

No. 4. "Mee oil from R. M. Udaisambera Urugela." It consisted of clean, granular fat of pale greenish-yellow colour.

No. 5. "Jaffna Illupai (Mee) oil." It was clean, semi-solid, pale yellowish-white fat.

The following table gives the results of examination of the two samples of fat as received from Ceylon:—

	No. 4.	No. 5.
Specific gravity at $\frac{100^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$ ...	0·861	0·861
Acid value	25·7	5·8
Saponification value	191·5	191·5
Iodine value	61·2	57·6
Titer test	40·2° C.	41° to 42° C.

On comparing the above results it will be seen that there is a considerable difference in the amounts of fat present in the three kinds of kernels, *B. butyracea* being richest, and *B. latifolia* the least rich in this respect. Recent analyses by Menon (*loc. cit.*) of Indian kernels from these three species gave results very similar to those now recorded, and confirm the view that the kernels of *B. latifolia* contain less fat than those of *B. longifolia*, and the latter, in turn, less than those of *B. butyracea*.

As regards the fats from these three kinds of kernels there is very little to choose between those furnished by *Bassia longifolia* and *B. latifolia*, but the fat from the kernels of *B. butyracea* is harder and whiter than those from the other two species, and should be more valuable commercially. It is understood that whilst *Bassia longifolia* and *B. latifolia* kernels are exported from India in large quantities, there is at present practically no export of *Bassia butyracea* kernels, apparently because all that are available are used locally for the production of edible fat.

Watt (*Commercial Products of India*, 1908, p. 120) mentions that the kernels of *Bassia butyracea* are regarded in India as yielding a more valuable fat than ordinary Mowra kernels, and the results now recorded confirm that view. It would seem to be desirable to encourage the export of *Bassia butyracea* kernels from India if enough are available for that purpose, and it would be well, in view of their richness in fat and the superior quality of this fat, that they should be marketed under a distinct name, so that they will not be sold in Europe as Mowra or Illipi kernels,

At present Bassia kernels are more popular with oil-seed crushers in Germany and France than in the United Kingdom. One reason for this appears to be that the cake left after expressing the fat is considered poisonous to cattle, owing to the saponin it contains, and consequently only fetches low prices, being used as a manure instead of as a feeding-stuff. Investigations recently carried out at Liverpool (*Bio-Chemical Journal*, February, 1910, p. 93) have shown that oil-cake made from the kernels of *Bassia longifolia* contains a saponin-like glucoside, which has a marked physiological action when injected subcutaneously, but does not appear to be very active when fed to animals. Careful feeding trials on a considerable scale with oil-cakes made from Bassia kernels would, however, have to be made before it would be safe to say whether or not such materials could be used as feeding-stuffs for cattle, and, even if they proved harmless, it is probable that their intensely bitter taste would preclude their use in this way.

The value of Mowra kernels is about £11 per ton (May, 1911). This price appears to be paid for kernels containing about 46 per cent. of fat, and it is clear that kernels in good condition and containing 54 or more per cent. of fat, such as the *B. longifolia* kernels from India and Ceylon, should bring somewhat higher prices under present conditions.

"Katiau" Seeds and Fat from British North Borneo.

Within recent years considerable quantities of oil-seeds have been exported from Sarawak under the name of "Illipé" seeds. These are derived from species of Shorea and Isoptera, belonging to the Dipterocarpaceæ, and must therefore be distinguished from the "Illipé" seeds of India, which are derived from Bassia spp. (see above). A true Bassia, known as "katiau," "katio," or "kachiau," however, does occur in Borneo, the fruits of which are much sought after by the natives, who use the fat contained in the seeds for cooking and other food purposes.

Samples of "katiau" seeds, and of fat prepared from them, were received from British North Borneo in September 1909, and the results of their examination are given below.

Herbarium specimens of the "katiau" plant, subsequently forwarded to the Imperial Institute, have been identified at Kew as a form of *Bassia Mottleyana*, C. B. Clarke (Sapotaceæ).

"Katiau" Seeds.—The sample consisted of brown, shiny seeds, measuring about $\frac{3}{4}$ in. by $\frac{3}{8}$ in., and resembling other small Bassia seeds in general appearance. The shells were thin and easily broken; the kernels were brownish, and in many cases covered with a black fungus. The seeds consisted of kernel, 68 per cent.; shell, 32 per cent. The average weight of a single seed was 0·34 gram.

The kernels yielded 51·3 per cent. of pale greenish-yellow solid fat, of soft consistence, equivalent to a yield of about 35 per cent. from the whole seed.

"Katiau" Fat.—This consisted of a yellow, pasty fat, having a strong smell of benzaldehyde (oil of almonds). It was at first

considered possible that the presence of benzaldehyde in this oil might have been caused by the action of an enzyme on a glucoside existing in the seed. If such were the case, however, the aldehyde would probably have been accompanied by prussic acid; whereas, although benzaldehyde was proved to be present in the oil, no prussic acid could be found. Moreover, no prussic acid or benzaldehyde could be detected in the "katiau" seeds themselves. In view of these facts it seems certain that a small quantity of benzaldehyde had been added to the oil for the purpose of scenting or flavouring it. In this connection it is interesting to note that a sample of native-prepared "katiau" fat, examined by C. J. Brooks (*Analyst*, 1909, **34**, 207), also had a pleasant odour of almonds.

The fat extracted from the seeds at the Imperial Institute and that sent from Borneo were examined with the following results, which agree fairly closely with those obtained by C. J. Brooks for the sample of native-prepared fat referred to above:—

	Fat extracted from seeds at the Imperial Institute.	Fat sent from Borneo.
Specific gravity at $\frac{100^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$ ...	0·885	0·864
Acid value	77·9	2·3
Saponification value	191·0	191·5
Iodine value	65·0	65·0
Titer test	36·4° C.	36·3° C.
Hehner value	—	96·0
Reichert-Meissl value	0·8	0·6

The high acid value of the fat extracted at the Imperial Institute is due to the fact that the seeds were old, and had become somewhat mouldy, with the result that the fat had decomposed to some extent. The specimen prepared in Borneo was doubtless obtained from fresh seeds.

The fat extracted at the Imperial Institute was found to consist principally of the glycerides of oleic and stearic acids, and probably also of palmitic acid. These glycerides appear to be present approximately in the proportions of olein, 75 per cent.; stearin (and probably palmitin), 25 per cent.

The fat closely resembles that of *B. latifolia*, but is somewhat softer. The kernels contain about the same proportion of fat as Indian "mowra" kernels, and would probably realise approximately the same price as the latter. This price was about £11 per ton in the United Kingdom in May 1911.

"Katiau" fat would find application in the manufacture of soap and candles, and possibly in the preparation of edible fats.

"MINYAK SURIN."

FEDERATED MALAY STATES.

The Imperial Institute received in 1904 an enquiry from a firm of soap-makers in the United Kingdom asking for informa-

tion as to the possibility of obtaining commercial supplies of the seeds of *Palaquium* (*Dichopsis*) *oblongifolium*, Burck, (N.O. Sapotaceæ), or the oil expressed from these seeds.

In dealing with this enquiry it was found that practically nothing was known about these materials in this country, and that the information available regarding them in English and foreign literature is apparently entirely derived from a statement made by Dr. Burck (*Mededeelingen uit 's Lands Plantentuin*, III., p. 40), that the seeds yield a hard, white fat known as "Njatoh" fat, chiefly composed of stearin and olein, and which would be suitable for the manufacture of stearin candles.

It was considered unlikely that this product would prove to be of commercial interest since it is well known that this species of Palaquium only occasionally furnishes seeds, and that consequently large supplies of the seed were not likely to be obtainable, but in view of Burck's statement as to the composition of the fat and the uses to which it could be applied it appeared to be worth while to obtain a sample of the material for examination. Application was therefore made to the Superintendent of the Botanic Gardens, Singapore, and to the Director of Museums at Perak, Federated Malay States, for samples of the seeds or the expressed oil, and for any information which might be available locally regarding either of these products.

In response to this request the Superintendent of the Botanic Gardens, Singapore, in a letter dated the 6th December, 1904, stated that the seeds of *Palaquium oblongifolium* were extremely rare; that on some occasions as much as a dollar for each seed had been offered without securing any supplies, and that although during the last few years small quantities of the seeds had become available in the Straits Settlements, it was improbable that any had been used for the extraction of fat.

Similarly the Director of Museums at Perak, in a letter dated the 16th December, 1904, said that he could hold out no hopes of being able to obtain either the fat or the seeds of *Palaquium oblongifolium*, as seeding trees of this species are rare, but the fat known to the Malays as "Minyak Surin," obtained from the seeds of a tree allied to *Palaquium oblongifolium*, could be secured in small quantities, and that he would send a sample of this material for examination.

The following information was given regarding Minyak Surin:—

"The Surin trees grow singly in the jungle, usually at wide intervals, so that the collection of the seed is a matter of difficulty. The Malays on finding a tree shedding its seeds, gather them up and after husking and sun-drying them, express the fat by means of a wedge-press called 'Apit Surin.' The fat does not come into the local market, but is used by the makers for cooking purposes. The fat could not be obtained in quantities at a price which would make it available for either soap- or candle-making."

The botanical name of the Surin tree was not supplied.

The sample of "Minyak Surin" received weighed about two pounds, and consisted of cylindrical pieces of solid fat, which

contained much dirt and foreign matter. The fat had a peculiar odour but was not rancid.

A portion of the sample was sent to Dr. J. Lewkowitsch, who had offered to investigate this material, and he was good enough to supply to the Imperial Institute the following observations with regard to it:

"The fat was very dirty and was filtered to remove insoluble impurities. The chemical examination gave the following results:—

Saponification value	... ...	179·5
Unsaponifiable matter	... ...	4·54
Free fatty acids	... per cent.	43·2
Iodine value	... ...	42·31
Reichert-Meissl value	... ...	0·55

"The mixed fatty acids were isolated from a portion of the fat and gave the following results:—

Solidifying point of mixed fatty acids	59·10° C.
Mean molecular weight of fatty acids	284·9
Proportion of stearic acid (m.p. 67·8° C.) in total fatty acids per cent.	58·2

"From the foregoing numbers the conclusion may reasonably be drawn that the fatty acids consist practically entirely of stearic and oleic acids, but a more thorough investigation would be necessary before this could be asserted definitely.

"The high proportion of stearic acid would render this fat a most useful raw material for the candle industry were it not for the presence of considerable amounts of unsaponifiable matter, which would be equally objectionable in soap manufacture. The commercial value of the fat would probably be from £24 to £26 per ton" (July, 1905).

It was pointed out in the letter accompanying this sample that owing to the sparse distribution of the Surin trees in the Federated Malay States this material could not be of any commercial importance since no large supplies of the seeds could be obtained, but it is interesting to note that the fat is suitable for industrial use and that it would probably sell at fairly high prices if it could be obtained in large quantities.

The observation that "Minyak Surin" consists of stearin and olein is also interesting as showing that its composition is similar to that ascribed by Burck to the fat obtained from the seeds of *Palaquium oblongifolium*, and in this connection it would be of some interest to know the botanical name of the Surin tree, in order that its exact botanical relationship to *Palaquium oblongifolium* might be ascertained.

DIKA NUTS (*Irvingia Barteri*).

SOUTHERN NIGERIA.

Samples of unshelled "dika nuts," of the so-called "dika" or "Gaboon chocolate," and of the sun-dried kernels of the nuts, were forwarded to the Imperial Institute for examination by H.M. Commissioner for Southern Nigeria in August, 1904.

"Dika" or "Gaboon Chocolate."—The sample consisted of a single round cake about 6 inches in diameter. It was of a dirty brown colour externally and was brownish-white internally. It was friable and possessed a mouldy odour, which was masked to some extent by the aroma of the pepper which had been incorporated with the material in preparing the cake.

This sample was compared with a specimen of "dika chocolate" supplied by the Director of the Royal Botanic Gardens, Kew. The Kew sample was similar to that sent from Southern Nigeria, but was somewhat harder, and internally was much darker in colour. It possessed also a curious aromatic odour quite distinct from that of the specimen from Southern Nigeria. The Kew sample appeared to have been cut from a circular cake about 6 inches in diameter. This so-called "dika chocolate" consists of the ground fresh kernels of the nuts, from which a portion of the fat has been removed, worked up into cakes with pepper and salt. The "chocolate" is a staple article of food among West African natives.

Undecorticated "Dika Nuts."—The supply of undecorticated nuts weighed about 50 lb. On examination it was found that only about 5 per cent. of the nuts were sound. This material was therefore unsuitable for detailed investigation.

Sun-dried Kernels.—About 3 lb. of this material were received. The kernels were prepared by cracking the nuts and drying the kernels in the sun. On cracking the nut the kernel splits into two halves, and this sample consisted almost entirely of such split kernels. The material was in good condition when received, and a portion of the sample which had been retained for reference showed no sign of decomposition after preservation for over a year. It is evident, therefore, that the sun-dried kernels, when carefully prepared, may be kept for some considerable time without undergoing decomposition.

Portions of the sample of "dika nuts" and of the kernels were submitted to an expert, and the following observations on these materials have been kindly supplied by him to the Imperial Institute:—

"The 'dika nuts' were examined immediately on arrival. The kernels in these were, however, found in so advanced a state of mouldiness that it was considered useless to extract any fat from them. The sound nuts yielded 20 per cent. of kernels. The sun-dried kernels were in a comparatively fresh condition; they contained 54·3 per cent. of fat. This fat, on examination, gave results indicating that it consisted principally of glyceryl esters of fatty acids less complex than stearic acid, the preponderating constituent being apparently lauric acid."

A more detailed account of the chemistry of the fat contained in "dika nuts" is given in a paper by Dr. J. Lewkowitsch, who worked with material supplied by the Imperial Institute (*Analyst*, 1905, **30**, 394).

The foregoing results indicate that the "dika fat" expressed from the sun-dried kernels would be suitable either for soap or candle manufacture, and for these purposes it would be worth from £25 to £27 per ton, and the "dika kernels" probably from

£10 to £12 per ton (August, 1906). It would not be advisable to ship the unshelled "dika nuts" from Southern Nigeria to this country, since the cost of transport would thereby be materially increased, and the cost of decortication in this country would be high, so that it is unlikely that the unshelled nuts could be sold here at a remunerative price.

Several other samples of the nuts and kernels from Southern Nigeria have been received, and the results of examination of these are given below. The proportion, by weight, of kernels in the nuts varied from 18 to 20 per cent.

—	Sample No. 1.*	Sample No. 2.	Sample No. 3.
Yield of fat (on kernels), per cent....	54·3	60·1	66·3
Specific gravity at 100°/15°C. ...	—	0·863	—
Acid value	6·6	12·6	1·8
Saponification value	244·5	250·0	243·8
Iodine value	5·2	3·3	4·2
Unsaponifiable matter	0·7	—	—
Titer test	34·8°C.	—	—
Melting-point of fat	—	—	39·2°C.

* This sample was examined by Dr. Lewkowitsch (*Analyst*, 1905, **30**, 394).

MAFOUREIRA SEEDS.

(*Trichilia emetica.*)

Portuguese East Africa.

The consignment of these nuts now dealt with came from Portuguese East Africa.

It consisted of ovoid fruits, about ¾ inch long and ½ inch broad, composed of a chocolate-brown shell, more or less covered with a reddish oily pulp, enclosing a single dull greyish-brown kernel, which readily splits into two parts. The kernels break with a granular fracture and readily yield oil under the pressure of the finger-nail.

The nuts were sent to a manufacturing firm for technical examination. The kernels yielded 54·46 per cent. of fat, and the husks 50·37 per cent.

The fats obtained from both the husks and kernels were solid and of dirty-green colour; they could not be bleached by any of the ordinary processes used in bleaching fat for soap manufacture.

	Fat from kernels.	Fat from husks.
Acid value	36·7	17·7
Saponification value	200·3	209·7
Iodine value	52·6	71·6
Titer test...	53·2° C.	45·4° C.
Unsaponifiable matter... ...	1·4	1·3

The fat obtained by expression from the seeds has also been examined by Daniel and McCrae (*Analyst*, 1908, **33**, 276), who found the following values: saponification value, 201; iodine value, 43·5; unsaponifiable matter, 1·2.

In reporting the results of the commercial trial, the firm stated that the dark colour of the fat would render it unsuitable for making the better qualities of soap, and that, in consequence, it would only realise the price of "soft, off-coloured tallow" for soap-making purposes.

The cake left after the extraction of the fat in these experiments contained a larger quantity of fat (25·8 per cent.) than would probably be left in the cake when working on the commercial scale. The yield of fat obtained from the nuts in actual manufacturing operations would therefore probably be larger than the figures recorded above. A chemical examination showed that the cake contained 3·49 per cent. of nitrogen, equivalent to 4·4 per cent of ammonia, and the equivalent of 1·5 per cent. of phosphoric anhydride.

These results show that the nuts furnish a satisfactory yield of solid fat, which is, unfortunately, of rather dark colour; and information received from other manufacturers who have tried this material as a source of fat, confirms the view that it is difficult to bleach. The cake left after the removal of the fat is unsuitable for use as a feeding material, since it is very bitter and probably possesses emetic properties.

A second supply of Mafoureira seeds was received at the Imperial Institute from the Companhia de Moçambique, in April, 1910.

This consignment was obtained in order that further technical trials might be carried out with the seed, oil, and residual cake.

The consignment weighed about 10 cwt., and was composed of seeds rather over ½ inch long and ¼ inch wide, which had brown papery husks and greyish-brown oily kernels. Each seed was partly covered with red oily pulp.

The bulk of the consignment was forwarded to a large firm of oil-seed crushers in order that the fat might be expressed and submitted to technical trials and that an examination might be made of the residual cake. The firm reported that the ordinary crushing machinery was not very suitable for dealing with these seeds, but that this would not be any objection if they are available in quantity, as special arrangements could easily be made.

Fat.—The entire seeds were found to contain 56·6 per cent. of fat, as compared with 56·3 and 54·2 per cent. in the case of two samples from Nyasaland (see p. 559).

The fat expressed from the seeds was a buff-coloured, solid, hard, and rather granular material. It furnished the following results on examination:—

	Fat from entire seed.
Specific gravity at 100°/15·5° C.	0·866
Acid value	19·0
Saponification value	205·4
Iodine value	50·0
Titer test	49·2° C.

The oil-seed crushers were of opinion that the fat would be suitable for the manufacture of soap, as it saponifies readily and yields a soap of good colour, most of the colouring matter of the fat remaining in the lye. They accordingly submitted it for

practical trial to a large soap-making firm, who reported that it was very satisfactory for this purpose, and that as it is a hard fat it should always find a ready sale among soap manufacturers. They considered that Mafoureira fat would compete favourably with Chinese vegetable tallow.

Another large firm of soap-makers who were consulted by the Imperial Institute reported that the colour of the fat would render it unsuitable for the production of first-class soaps.

Cake.—The residual cake obtained in the crushing trial was a light, brown, soft, friable material with a very bitter taste. It contained 28·6 per cent. of fat, which is a much higher proportion than would be left in the cake when working with suitable machinery on a commercial scale. Trials showed that the cake could not be utilised as a feeding-stuff. It was found impossible to induce sheep to eat it, even when mixed with other rations, evidently on account of the intensely bitter taste.

The cake contains very little nitrogen and phosphoric acid, and is not likely to be of much value as a manure (see p. 557), but further experiments on the subject are in progress.

The firm of oil-seed crushers considered that the fat expressed from Mafoureira seeds would be worth about £30 per ton in the United Kingdom (January, 1911), and that the value of the seeds, based on the above value of the fat and on the value of the cake as manure, would be £10 to £11 per ton in the United Kingdom. The firm added that a better market might possibly be found for the cake and that if so, the value of the seeds would be correspondingly increased.

The price of £10 to £11 per ton quoted above for Mafoureira seeds was higher than an offer of £9 5*s*. per ton which was made by a firm of London brokers in 1906 for a consignment of this seed. This increase in value was due to the fact that all oil-seeds had risen considerably in price in the interval.

It is clear that a good market should be found for Mafoureira seeds in the United Kingdom if they can be shipped regularly in commercial quantities, and in good condition.

It has been stated recently that a smaller variety of Mafoureira seeds has appeared on the market, which invariably contain a much smaller proportion of fat than the large variety, *e.g.*, 26 to 34 per cent., against over 50 per cent. in the samples of the large seeds examined at the Imperial Institute. It is, of course, important that these small seeds should not be mixed with the large seeds for export.

NYASALAND.

In Nyasaland the nuts of *Trichilia emetica* are known by the native name "Msichitsi." Those which are the subject of this Report were forwarded to the Imperial Institute by the Chief Forest Officer at Zomba in March, 1909.

Two samples, collected at different elevations, were forwarded and it was desired to know whether there was any variation in the amount of oil present.

1. "Msichitsi nuts (*Trichilia emetica*) from Karonga district, grown at an altitude of about 1,250 feet."

These nuts had the usual appearance of the seeds of *Trichilia emetica* (Mafoureira nuts). The husks were thin, and easy to detach.

2. "Msichitsi nuts from Zomba, grown at an elevation of about 2,900 feet above sea level."

These nuts were like those of sample No. 1, but the husks were thicker and softer, and not so easily removed from the kernel as in the previous case. The sample was dusty, and otherwise less clean than sample No. 1.

The composition of the two samples was as follows:—

	No. 1. Per cent.	No. 2. Per cent.
Kernel ...	75	65
Husk	25	35

The percentage of fat in the two samples was determined with the following results:—

Fat from	No. 1. Yield per cent.	No. 1. Description of fat.	No. 2. Yield per cent.	No. 2. Description of fat.
Whole seeds ...	56·3	Buff-coloured, solid ...	54·2	Brown, solid.
Husks	42·9	Pale yellow, semi-solid	45·5	Brown, semi-solid.
Kernels ...	61·3	Pale brown	60·0	Pale brown, solid.

The above results show that both samples are of the usual quality. The yields of fat do not differ sufficiently to enable any conclusions to be drawn as to the effect on the yield, of the altitude at which the trees are grown. The proportions of fat in commercial samples of Mafoureira nuts show a much greater variation.

LOPHIRA ALATA SEED AND OIL.

Sierra Leone.

Supplies of the seeds and fruits of this tree, which is widely distributed in Sierra Leone, and, indeed, throughout the coastal districts of West Africa, were received in June, 1907, at the Imperial Institute from Sierra Leone for examination as an oil-seed, it being thought that the product would be likely to be of some commercial importance since the seeds are obtainable in large quantities in readily accessible areas. The tree is already well known as one of the sources of the so-called African oak, whilst the oil prepared from the seeds is known in Sierra Leone as "Niam" fat or "Meni" oil.

In all, five samples of the seeds and fruits have been received for examination from Sierra Leone.

Fruits.—These were roughly conical and each consisted of a reddish-brown, fibrous shell, usually about $\frac{1}{32}$ inch thick, enclosing a single seed or kernel. The fruits consisted of about

40 per cent. husk and 60 per cent. kernel. In many of the fruits received the kernels had undergone partial decomposition, and were dark brown, instead of almost white, internally.

Kernels.—These were conical in shape about ⅝ inch in length, and ½ inch broad at the base. Externally they varied in colour from orange-brown to, in a few cases, greenish-black. Internally they were almost white or pale yellowish in colour when fresh, but tended to become brown when kept, and this darkening in colour seemed as a rule to begin at the apex. They contained a semi-solid yellowish-white fat, and the amount of this present varied in the samples examined from 31·1 to 43·0 per cent., the variation being due apparently to three causes: viz., differences in (1) the maturity of the fruits when collected; (2) in their condition, as regards freshness, and (3) in dryness of the kernels examined.

Characters of the Fat.

Small quantities of the almost white or pale yellow semi-solid fat present in the kernels were prepared from each of the products received, and these were chemically examined. The results obtained are given in the following tables:—

Table I.

Yield of Fat.

	A.	B.	C.	D.	E.
Product received	Fruits.	Kernels.	Fruits.	Kernels.	Kernels.
Condition of kernels ...	Mostly sound.	Good.	Many partly decomposed.	Good.	Fairly good.
Yield of fat (per cent. calculated on the weight of kernels used).	31·19	43·0	39·6	41·16	41·76

Table II.

Constants of Fat.

	A.	B.	C.	D.	E.
Specific gravity 40°/40° C.	0·9105	0·9044	0·9044	0·9019	0·9016
Acid value	18·54	25·9	33·2	47·5	48·0
Saponification value ...	195·6	181·5	194·6	180·7	183·3
Iodine value	68·4	69·8	70·3	72·1	72·5
Reichert-Meissl value ...	—	0·9	0·9	0·8	0·8
Unsaponifiable matter ...	1·49	0·5	—	—	0·86
Titer test	—	49·0° C.	47·0° C.	47·5° C.	48·5° C.

It will be noticed that the decorticated kernels are somewhat richer in oil than those which were exported in an undecorticated

state, for the reasons already given. In the case of the last two samples of decorticated kernels, the oils prepared from them are more rancid, as indicated by the higher acid values, than those obtained from the kernels exported in the shell, but the difference is not marked, and scarcely affects the commercial value of the oil. It is curious that the oils from the decorticated kernels have uniformly lower saponification values than the oils from the undecorticated kernels, but this difference is probably of little importance.

It is clear from these results that it will be advantageous to export the kernels in a decorticated state to save freight and the cost of decortication in Europe, and that so long as the decorticated kernels are thoroughly dried before export there is no likelihood that they will reach Europe in an unsatisfactory condition. Further, the results of the examination of sample E, which was stored in the Colony during two months of the rainy season before shipment to this country, indicate that the kernels do not deteriorate much as the result of storage in a moist atmosphere. A portion of the consignment B was submitted to a firm of soap manufacturers in order that the oil might be expressed on a small commercial scale and tried for soap-making. This firm reported that the decorticated seeds yielded 43·4 per cent. of oil, which for their purposes would be worth from £1 to £2 per ton more than cotton-seed oil under ordinary market conditions.

A small sample of the kernels was also submitted to a firm of oil-seed crushers, who confirmed the above valuation of the oil, and valued the kernels provisionally at £10 per ton, c.i.f., Liverpool, June, 1908. It remains to be seen whether this price will, after paying for the collection of the fruits and their decortication in Sierra Leone, leave a margin large enough to induce traders to ship this product.

A large consignment of the kernels was received subsequently from Sierra Leone in September, 1910. They had been obtained from fruit collected in the Karene district of the Protectorate.

The consignment, which consisted of 112 bags, each containing two bushels of kernels, was forwarded to a large firm of oil-seed crushers in Liverpool, who had undertaken to carry out technical trials with the material.

The oil-seed crushers reported that the kernels contained about 40 per cent. of fat, which agrees with the figures obtained for the previous samples from Sierra Leone examined at the Imperial Institute (see above). After a number of trials to determine the best method of extracting the fat on a commercial scale, the kernels were crushed, and samples of the fat and of the residual cake were supplied to the Imperial Institute for detailed investigation.

(1) *Fat.*—The sample consisted of a clean, pale buff-coloured solid fat, having a slight, but not unpleasant, odour and taste. It was examined with the following results, compared with those recorded for previous samples of *L. alata* fat:—

	Present sample.	Previous samples examined at the Imperial Institute.
Specific gravity at $\frac{100° C.}{15° C.}$	0·859	—
,, ,, $\frac{40° C.}{40° C.}$	—	0·9016 to 0·9044
Acid value	26·0	25·9 ,, 48·0
Saponification value ...	188·9	180·7 ,, 183·3
Iodine value	68·0	69·8 ,, 72·5
Titer test	45° C.	47·5° ,, 49° C.
Unsaponifiable matter ...	2·5 (approx.)	0·5 ,, 0·86

The present sample of fat, therefore, resembles the specimens extracted at the Imperial Institute in 1908 (see p. 560).

For a detailed account of the chemistry of this fat, see "The Composition of the Fat from the seeds of *Lophira alata*," by Messrs. Pickles and Hayworth (*Analyst*, 1911, **36**, 493).

(2) *Cake.*—This material was forwarded to the Imperial Institute in the form of rectangular cakes, of chocolate-brown colour, and presenting a mottled appearance internally when broken. The taste was bitter and strongly astringent, indicating that the material would be unsuitable for feeding purposes and could only be utilised as a manure.

The cake was analysed with the following results, expressed on the material as received:—

	Per cent.
Moisture	8·50
Ash	4·48
Nitrogen	1·87

The ash contained:—

		Per cent.*
Potash	K_2O ...	1·91
Lime	CaO ...	0·18
Magnesia	MgO ...	0·30
Phosphoric acid	P_2O_5 ...	0·51

These results indicate that *L. alata* cake is suitable for use as a manure, but is of rather lower value for the purpose than castor-seed cake, rape-seed cake, cotton-seed cake, and similar materials.

Commercial Valuation.

(1) *Fat.*—*L. alata* fat is suitable for soap-making, and the firm of oil-seed crushers who expressed the present sample ascertained that its value for the purpose would be about the same as that of palm oil, viz., about £30 to £31 per ton in Liverpool (November, 1911).

The fat was submitted to two firms with a view to ascertaining its suitability for edible purposes, but in both cases the report was unfavourable owing to the taste and the high acid value of the material. The oil-seed crushers also considered that the cost of sufficiently refining the fat would preclude its use in this way.

* Expressed on the cake.

(2) *Cake.*—The oil-seed crushers stated that this material closely resembles shea-nut cake, and they considered that it would have a similar value, viz., about £3 per ton in Liverpool (November, 1911). This value is rather above the average; the price fluctuates between this and 45*s.* per ton.

(3) *Decorticated seed.*—The oil-seed crushers reported that the decorticated seed (kernels) with which they carried out the experiments contained about 40 per cent. of oil, and on this basis they valued the kernels at about £10 per ton c.i.f. Liverpool (October, 1911).

It is clear from the foregoing results that the decorticated kernels of *L. alata* should find a ready market in Europe as a source of oil for soap-making, and that the cake left after expression of the fat could be utilised as a manure.

SUDAN.

A sample of oil prepared in the Sudan from the seeds of *Lophira alata* has also been received for examination. The product is known in the Sudan as "Zawa" oil.

The sample consisted of a dark orange-brown oil, containing a little sediment. The chemical examination of the oil gave the following results, for comparison with which the figures obtained in the laboratories of the Gordon College, Khartoum, for another sample of Zawa oil, are added:—

	Sudan sample sent to Imperial Institute.*	Sudan sample examined at Gordon College Laboratories.
Specific gravity at 40°/40° C.	0·9063	0·8615†
Acid value	5·78	—
Saponification value	190·10	177·1
Unsaponifiable matter... ...	1·38	—
Iodine value	78·12	72·7
Titer test	42·5° C.	—

The oils extracted from the Sierra Leone seeds at the Imperial Institute were almost white or pale yellow and semi-solid, whereas the oil received from the Sudan was much darker in colour and liquid, though it deposited a good deal of solid matter on standing.

The Sudan oil had an unpleasant taste, but Dr. Beam of the Gordon College laboratories records that the oil he examined had an agreeable flavour, somewhat recalling that of arachis oil. All the oils prepared at the Imperial Institute from seeds received from Sierra Leone had a slight unpleasant taste, and the residual cake was bitter.

* The Sudan sample was examined for the Imperial Institute by Dr. Lewkowitsch, and is described in the *Journ. Soc. Chemical Ind.* (1907, 26, 1265).

† Specific gravity at 100°/15° C.

LOPHIRA PROCERA SEEDS.

GOLD COAST.

A sample of "Kaku" seeds (*L. procera*) collected at the Agricultural Station, Tarquah, Gold Coast Colony, was received for examination at the Imperial Institute in April, 1911.

The seeds were roughly conical, each containing a single kernel. The shells were reddish-brown, thin, fibrous, and easily broken; the kernels were soft, and white to brown in colour internally.

The seeds consisted of shell, 25 per cent.; kernel, 75 per cent. The average weight of a single seed was about 0·83 gram, and of a kernel about 0·62 gram.

The kernels yielded 55·3 per cent. of cream-coloured, solid fat, and they contained 8·7 per cent. of moisture.

The fat was examined chemically, with the following results:—

Specific gravity at $\frac{100^\circ \text{ C.}}{15{\cdot}5^\circ \text{ C.}}$	0·859
Acid value	11·6
Saponification value	190
Iodine value	60
Unsaponifiable matter	0·8

The kernels of these seeds of *L. procera* yield a larger percentage of fat than those of *L. alata*, but the fat from both kinds of seed is of a similar character.

A sample of the *L. procera* kernels was submitted to a large firm of oil-seed crushers for technical trials. They reported that the fat would be suitable for soap-making. The residual cake has a bitter taste, and would consequently be of no value as a feeding-stuff; it could be used as a manure, but as it contains only 3½ per cent. of ammonia, it would not be worth more than about 35*s.* per ton for this purpose.

On the above basis, the firm valued the decorticated kernels of *L. procera* at about £12 per ton delivered in Liverpool (February, 1912).

CARAPA SEEDS.

Oil-seeds from several species of Carapa have been received at the Imperial Institute for examination. As there appears to be a good deal of confusion in the technical literature regarding the botanical origin of the various Carapa seeds and oils which have appeared in commerce from time to time or have been investigated by chemists, it will be convenient to summarise here the distribution of the various oil-seed yielding Carapa species and their synonymy. For the latter purpose, De Candolle's monograph on the order Meliaceæ, in which the genus is placed, is taken as the authority.

Carapa procera, DC.—*C. Touloucouna*, Guill. et Perr.; *C. guineensis*, Juss.; *C. guyanensis*, Oliv. This occurs in the Antilles, Guiana, Senegambia and tropical Africa.

Carapa guianensis, Aubl. = that of Oliver's Flora of Tropical Africa, *pro parte*. This is found in Guiana, Martinique, San Domingo, Guadeloupe, Venezuela and Brazil.

Carapa moluccensis, Lam. Occurs in East Africa, Seychelles, etc.

Carapa grandiflora, Dawe and Sprague. Occurs in East Africa and Uganda.

SIERRA LEONE.

This consignment described as *Carapa guyanensis* (*C. procera*, *DC.*) consisted of characteristic roughly tetrahedral seeds, each having a rather rough reddish-brown shell enclosing a single kernel covered with a pale brown papery skin. When fresh the kernels appear to nearly fill the shells, but in this consignment most of them had dried and shrunk, assuming irregular shapes. The consignment contained about 35 per cent. good kernels, 27 per cent. bad kernels, and 37 per cent. shell.

The good kernels yielded about 57 per cent. of oil by extraction with solvents, and 46·7 per cent. by expression, 24 per cent. being obtained in the cold and 22 per cent. on heating and further expression.

The "cold pressed" and "hot pressed" oils presented much the same appearance, being viscous dirty-brown liquids, and possessing a slight, characteristic odour, and extremely bitter taste.

	Cold pressed oil.	Hot pressed oil.
Specific gravity at 40°C.	0·9179	0·9174
,, ,, 15°C.	0·9272	0·9327
Saponification value	197·1	196·4
Iodine value	75·6	71·2
Reichert-Meissl value	3·5	3·1
Unsaponifiable matter	1·5	2·0
Titer test	35·4°C.	36·1°C.

A portion of the "hot pressed cake" obtained in the technical trials referred to above was analysed, and gave the following results:—

	Per cent.
Moisture	9·8
Ash	5·9
Nitrogen	2·9

The ash contained:—

		Per cent.*
Potash	K_2O	1·91
Lime	CaO	0·18
Phosphoric anhydride ...	P_2O_5	0·51

These results indicate that the Carapa cake would be of rather low manurial value as compared with castor-seed cake, rape-seed cake, cotton-seed cake, and similar materials used as manures and would perhaps be worth about £2 per ton.

A further consignment of about 2¾ cwt. of *Carapa procera* kernels from Sierra Leone was received at the Imperial Institute in June, 1909, and as these were similar to those previously received, they were not chemically examined, but were forwarded to a firm of oil-seed crushers who extracted the oil and submitted

* Calculated on the cake.

it to soap and candle manufacturers in the United Kingdom for trial. As a result, it was found that the oil would be suitable for these purposes and on the basis of these trials the firm of oil-seed crushers agreed to take a trial consignment of 50 tons of kernels for which they would be willing to pay £11 5*s*. per ton for "dark kernels" and £11 10*s*. per ton for "light kernels" (November, 1909).

The price offered is somewhat higher than that estimated for the previous samples. This is in part due to the better condition of the present consignment, but chiefly due to the considerable rise in price of fats and oils since the previous samples were reported on.

Gold Coast.

A supply of seeds from this Colony, referred to *Carapa guineensis* (*C. procera*, DC.) was received early in 1907. They were irregularly tetrahedral in shape and had a brittle husk, which could be easily separated. The kernels were white and spongy, and had an intensely bitter taste. The husks constituted 25·7 per cent. by weight of the seeds. The yield of oil was 49·3 per cent. from the kernels, equivalent to 36·6 per cent. on the whole seeds.

The oil was pale yellow and had a bitter taste; on standing, it partially solidified to a white mass. It is not readily extracted from the seeds by light petroleum. The oil had the following constants:—

Specific gravity	0·917
Acid value	5·4
Saponification value	196·9
Iodine value	65·7
Hehner value	93·1
Titer test	36·0° C.

Uganda.

This consisted of the seeds of *C. grandiflora* and was forwarded from Entebbe in September, 1907.

The nuts were larger than those of *C. procera*, but resembled them in shape and appearance. The kernels were moist, soft and fleshy, and consequently contained much less oil than those of an earlier sample from Uganda, which were dry and shrivelled. A fair proportion of the kernels was bad, and these were not used in the investigation.

On extraction with solvents the kernels furnished 30·2 per cent. of oil, compared with 52 per cent. from the dry kernels of a previous consignment. The kernels were also submitted to technical trials, and it was found that on cold expression, using a pressure of 150 atmospheres, they furnished 10 per cent. of a pale yellow oil, which deposited a small amount of solid matter on standing. On further expression, at a temperature of 150° F., a quantity of darker coloured semi-solid oil was obtained. Both oils were intensely bitter.

The chemical examination gave the following results:—

	Cold pressed oil.	Hot pressed oil.
Specific gravity	0·9261	0·9306
Saponification value ...	198·1	201·8
Iodine value	83·7	72·6
Unsaponifiable matter ...	3·75	1·59
Titer test	34·9° C.	38·9° C.

The residual cake was very bitter, and only suitable for use as manure. It contained the following percentages of constituents of manurial value: nitrogen, 2·07; potash, 1·18; phosphoric anhydride, 0·603; and lime 0·296.

Comparison of Carapa Oils.

In view of the fact that the oils now dealt with came from two different species and three different localities, it is of interest to give in one table the results obtained with them, and to add figures for a sample of oil from seeds of *Carapa guianensis*, Aubl., from Trinidad, previously examined. (See *Technical Reports*, published by the Imperial Institute, 1903, p. 135.)

Source of oil.	Country of origin.	Specific gravity.	Acid value.	Saponification value.	Iodine value.	Hehner value.	Titer test.
							°C.
C. procera ...	Gold Coast...	0·917	5·4	196·9	65·7	93·1	36·0
" ...	Sierra Leone	0·927*	—	197·1	75·6	—	35·4
		0·932†	—	196·4	71·2	—	36·1
C. grandiflora	Uganda	0·9261*	—	198·1	83·7	—	34·9
		0·9306†	—	201·8	72·6	—	38·9
C. guianensis...	Trinidad ...	0·9225	—	195·6	65·0	93·7	—

* Cold pressed oil. † Hot pressed oil.

It will be seen that the oils exhibit a close general resemblance, and it would appear likely that the composition of the oils derived from the three species differs but little. It is also remarkable that the seeds of all three species are very bitter. This bitterness appears to be due to a resinous substance soluble in alcohol.

Commercial Value.

The technical expert who carried out trials with samples of Carapa seeds from Sierra Leone, Gold Coast, and Uganda, valued the oil at about £20 10*s*. per ton, and stated that as the residual cakes were very bitter they could not be used for feeding purposes. As the analyses given above show that these cakes are also of low manurial value it is probable they would not be worth more than £2 per ton.

PYCNANTHUS SEEDS.

Fruits, seeds and mace derived from *Pycnanthus* spp. have been received from Northern Nigeria, Sierra Leone and Uganda for examination as oil-yielding materials.

NORTHERN NIGERIA.

The fruits of a species of Pycnanthus, probably *Pycnanthus Kombo*, Warb. (N.O. Myristicaceæ), were included in a collection of products from Northern Nigeria, sent to the Imperial Institute in 1906.

The fruits were of the size of a small oval plum, and in the dry state weighed about 4 grams. They were easily broken into two thick hard pieces of husk, and an inner nut covered with a false aril, corresponding to the mace of the common nutmeg derived from *Myristica fragrans*, to which the genus Pycnanthus is nearly allied. The Pycnanthus seeds, it should be stated, are sometimes mistaken for nutmegs, though they have no aroma and are devoid of volatile oil.

The "mace" was deep brown, almost black, in colour. It possessed a slight fragrance, and was therefore examined for essential oil, but no appreciable quantity was present.

The nuts had a very thin shell, which was easily removed from the contained kernel. The latter was white internally, with dark brown rays penetrating it from the exterior; it was easily cut and had a very bitter taste, which would preclude the possibility of utilising the "cake" left after the extraction of the fat as a cattle food. The ground kernels were extracted by light petroleum, and yielded 54 per cent. of hard solid fat, of orange colour and bitter taste. It had the following constants:—

Specific gravity at 100°/15° C. ...	0·886
Melting-point	48·5° C.
Saponification value	235 to 245
Acid value	21·0
Hehner value	90·8
Iodine value	48·9
Titer test	45·8° C.

The fat would probably be suitable for soap-making, though the soap made from it would be rather dark in colour. It might also be used in the manufacture of candles.

The residual meal is fairly rich in nitrogen, and might be used as a manure.

SIERRA LEONE.

Samples of the fruits and the fat of *Pycnanthus Kombo*, Warb., were forwarded in March, 1911, from Sierra Leone, where the fruits are known as "Kpoye" nuts. The nuts were similar in shape to those from Northern Nigeria, but were smaller, weighing on the average 1·17 grams each. They consisted of a brittle, almost black shell enclosing a single greyish-brown kernel. The latter consisted of a hard whitish substance marked by brown infoldings of the skin. The shell formed 20 per cent. and the kernel 80 per cent. of the whole nut.

The kernels contained 70·7 per cent. of solid brown fat. That extracted from the kernels at the Imperial Institute resembled the fat sent from Sierra Leone but was of a lighter colour. Both had an unpleasant odour and bitter taste.

The fat from Sierra Leone and that extracted from kernels at the Imperial Institute were examined with the following results:—

	Fat as sent.	Fat extracted from kernels at the Imperial Institute.
Specific gravity at 100°/15·5° C.	0·887	0·880
Acid value	33·0	31·4
Saponification value	231	236
Iodine value	67·6	59·0

The slight differences in the constants of the two fats are probably due to differences in the method of preparation; and both are similar to the samples of fat from the kernels of (1) *Pycnanthus Kombo* from Northern Nigeria (see p. 568), and of (2) *P. Schweinfurthii* from Uganda (see below).

The results of examination show that "Kpoye" kernels are very rich in a solid brown fat, much richer than the samples of *Pycnanthus* kernels from Northern Nigeria and Uganda.

The kernels of *P. Kombo* are probably identical with a product known as "kafu" nuts (really kernels) which have from time to time been shipped from West Africa to Liverpool and Hamburg, and which are stated to contain 73 per cent. of solid fat. Two difficulties have been experienced so far by manufacturers in dealing with these kernels, viz., that the supplies are small and irregular, and that owing to its colour the fat requires refining by a special process, which involves a considerable loss of material. This latter difficulty is probably not a serious one, in view of the fact that the Sierra Leone kernels are so rich in fat. It is, however, important, before calling the attention of manufacturers to these kernels as an oil-seed, to ascertain whether they are obtainable in Sierra Leone in large quantities and in localities so situated that the cost of transport to the coast will not be prohibitive.

Uganda.

The material received from Uganda consisted of the nuts and mace of *Pycnanthus Schweinfurthii*, Warb.

Nuts.—These were small nut-like seeds, the shells of which were thin, fragile, dark brown and glossy, with irregular, longitudinal furrows. The kernels were small, egg-shaped, ¾ inch long and ½ inch broad at the widest end; they were brown externally, and yellowish-white internally, with isolated brown patches due to invaginations of the seed coat.

The kernels yielded to solvents 60·2 per cent. of fat, which was fairly hard at ordinary temperatures (15° C.), and was of dark brown colour; it had a slight peculiar rancid odour, and a faintly bitter taste. On examination it gave the following results:—

	Crude Fat.	Refined Fat.
Specific gravity at 99°/15° C.	0·887	—
Acid value	26·5	Nil.
Saponification value	255·0	183·0
Iodine value	65·4	33·7
Hehner value	90·9	—
Titer test	37° C.	37·6° C.

The fat extracted from the kernels possessed a high acid value, and darkened in colour when treated with alkalis. Consequently it would have to be refined before being used for soap-making. The only satisfactory method of accomplishing this is to treat the fat with alkalis, which involves the loss of all the free fatty acids. The refined product thus obtained, the constants of which are given in the second column of the table, is a clear, pleasant-smelling, butter-yellow fat, suitable for soap-making. The firm of soap-makers who examined these nuts for the Imperial Institute stated that the heavy loss involved in refining the oil renders it doubtful whether the nuts could be successfully utilised commercially, but as the kernels are very rich in fat it is possible that it would be worth while to make use of them, especially if they are obtainable in very large quantities at a low cost.

"*Mace.*"—This consisted of flat, dark, orange-brown, oily pieces, ½ to 1¼ inch long, resembling ordinary "mace" in form, but smaller, darker in colour, and devoid of aroma. The taste was oily, bitter and acrid. The material yielded to solvents 57·04 per cent. of oil. This was of dark, orange-red colour, fluid and translucent in thin layers at first, but on standing it deposited a considerable quantity of a semi-crystalline substance. It developed a deep violet colour when treated with alkalis.*

Specific gravity at 99°/15° C. ...	0·866
Acid value	40·7
Saponification value	214·0
Iodine value	77·45
Hehner value	91·2
Titer test	35° C.

Owing to the dark colour of the oil, which can only be decolorised satisfactorily by treatment with alkali, involving the removal of the large amount of free fatty acid present, it seems unlikely that this "mace" can be used commercially as a source of oil. The product is devoid of aroma, and cannot therefore be used as a substitute for true mace.

PENTADESMA BUTYRACEA KERNELS AND FAT.

SIERRA LEONE.

A small sample of this fat received in July, 1908, from Sierra Leone, consisted of pale, greyish-coloured, granular fat, with a slight odour like that of Shea butter. The fat contained a good deal of suspended impurity, and after filtration and cooling had a greenish-yellow tinge.

Specific gravity at 100°/15·5° C. ...	0·859
Acid value	3·6
Saponification value	190·1
Iodine value	41·8
Titer test	50·7° C.
Hehner value	95·0
Unsaponifiable matter	1·7
Reichert-Meissl value	Nil.

* This substance might be included more appropriately with the liquid or semi-liquid non-drying oils, but it is convenient to place it near the Pycnanthus seeds from which it is derived.

From its appearance and chemical constants it seems possible that this fat might be used for the manufacture of edible fats; but practical trials would be necessary to determine this. If unsuitable for the above purpose it might find a market for candle manufacture, in which case, however, its value would not be so high. If available in large quantities this fat would no doubt be saleable in this country, but technical trials on a large scale would have to be made in order to ascertain its commercial value definitely.

Southern Nigeria.

A small supply of kernels of *Pentadesma butyracea* was received from Southern Nigeria in April, 1911. It consisted of large brown kernels, irregular in shape and dirty pink to brown internally. The kernels were very moist when received, and on drying in the air they lost about 34 per cent. of their original weight. The air-dried kernels averaged 12 to 13 grams each in weight, and then contained 10·6 per cent. of moisture and yielded 40 per cent. of fat.

The fat was of a pale yellow colour and had a pleasant smell and taste.

Specific gravity at 100°/15·5° C. ...	0·857
Acid value	3·1
Saponification value	186·0
Iodine value	46·5

A sample of the kernels was submitted to the firm who had applied to the Imperial Institute for information regarding the possibility of obtaining commercial supplies. They reported that samples of *Pentadesma butyracea* kernels which they had examined showed considerable variation in the yield of fat, largely owing to imperfect drying and differences in the degree of ripeness. They also stated that the fat is highly coloured and needs refining before it can be used to advantage in soap-making, whilst the residual cake is of no value as a feeding-stuff for cattle. In view of these facts they considered that the probable value of *Pentadesma butyracea* kernels would be £8 to £10 per ton in the United Kingdom, if imported in good, dry condition.

Other samples of *Pentadesma butyracea* kernels received at the Imperial Institute from British West Africa have yielded much smaller quantities of fat than the sample just described, thus confirming the manufacturers' statements that the kernels are variable in quality. In preparing the kernels for export it is desirable that only mature seeds should be collected and that the kernels should be thoroughly dried in the sun before being shipped.

SALVADORA PERSICA SEEDS.

Sudan.

S. persica, L., is a diffuse shrub or small tree belonging to the natural order Salvadoraceæ, which is found in a wild state thoughout the Sudan, where it is known as "mustard tree."

The seeds received at the Imperial Institute were round, averaging about 0·15 inch in diameter, with thin shells of greyish colour, in many cases slightly mottled with brown. The kernels, which were bright yellow, possessed an unpleasant, bitter taste. The seeds yielded 44·6 per cent. of hard, bright yellow fat, with a faint, slightly unpleasant odour.

The fat was examined with the following results, compared with that from the seeds of *S. oleoides* from India:

	Present sample of *S. persica* seeds.	Seeds of *S. oleoides* from India.*
Specific gravity at $\frac{99^\circ C.}{15^\circ C.}$	0·867	0·908 (at 50° C.)
Acid value	9·3	11·3
Saponification value ...	245·2	242·4
Iodine value	5·9	7·5
Titer test	30·4° C. (approx.)	40° C.
Melting point	38° C.	41° C.

The sample of the seeds was too small for commercial valuation. It may, however, be pointed out that the hardness and high melting-point of the fat render it suitable for the manufacture of candles, and if its unpleasant odour and taste could be removed by purification on a commercial scale it might possibly be employed in the preparation of vegetable butters and "chocolate fats."

In the Indian *Agricultural Ledger*, 1908, No. 1, *S. persica* and *S. oleoides* are considered to be distinct species, but in the *Index Kewensis* they are regarded as identical. The fat extracted from the present sample of seeds resembles that described in the *Agricultural Ledger* as the fat of *S. oleoides*, and as the botanical identity of the Sudan plant would therefore be of interest, specimens have been requested for determination.

"CHEYI" SEED.

NORTHERN NIGERIA.

The name "Cheyi" is applied by the natives of Northern Nigeria to *Polygala butyracea*, Heck., a herbaceous plant occurring commonly in tropical West Africa. The seeds of this plant contain a valuable fat which can be utilised for edible purposes, whilst the stems yield a fibre which is used by the natives for making fishing nets, cloth, thread, &c. A sample of the seed from Northern Nigeria has been examined.

The sample consisted of flat, oval seeds, about $\frac{1}{5}$ inch long and $\frac{1}{10}$ inch broad, brownish-black externally and greenish-yellow within. Some husks and other extraneous matter were present. The seeds yielded 37·9 per cent. of soft, yellowish fat, which possessed a pleasant taste and no distinctive odour.

The fat was examined with the following results, compared with those previously recorded for "Cheyi" fat:

* Hooper (*Indian "Agricultural Ledger,"* 1908, *No.* 1).

	Present sample.	Results previously recorded.
Melting-point ...	36° C.	—
Specific gravity at $\frac{100^\circ C.}{15 \cdot 5^\circ C.}$	0·868	—
Acid value	1·24	11·4
Saponification value ...	251·0	253·0
Iodine value	52·5	49·4
Titer test	37·85° C.	—
Hehner value	85·6	—
Reichert-Meissl value	45·6	45·5

The fat contained 0·55 per cent. of unsaponifiable matter.

Samples of the seeds were submitted for valuation to makers of edible fats and to oil-seed crushers, who furnished the following reports:—

(1) The makers of edible fats were of opinion that "Cheyi" fat would be very suitable for their purposes if the seeds arrived in the United Kingdom in good condition, and were proved to contain no poisonous constituents. On the basis of the yield of fat, they valued the seeds at about half the price of copra, which is now selling in the United Kingdom at £27 15s. to £29 10s. per ton (March, 1913).

(2) The oil-seed crushers also regarded the seed and fat as likely to be of considerable commercial value. They were of opinion that the fat should eventually realise a good price for edible purposes. Assuming that the residual cake would be suitable for feeding cattle, a point that will have to be determined by further examination and trial, they considered the seed to be worth at least £12 per ton in the United Kingdom, and expressed a desire to receive a trial consignment of 100 tons, at this price, as a commencement.

GORLI SEEDS.

Sierra Leone.

Two samples of this seed from Sierra Leone were received in June and August, 1908. A specimen of the plant was forwarded to the Imperial Institute in July, 1908, and this was submitted to the Royal Botanic Gardens, Kew, where it was identified as *Oncoba echinata*, Oliver (N. O. Bixaceæ). The samples of seed were as follows:—

No. 1.—This consisted of small, rather irregularly-shaped seeds, from $\frac{1}{4}$ to $\frac{3}{8}$ inch long, and $\frac{1}{8}$ to $\frac{3}{16}$ inch wide at the broadest part. The average weight of a single seed was 0·046 gram. Each seed was enclosed in a stiff brown seed-coat. Internally, the seeds were white, waxy in appearance, and soft, but they did not yield visible oil when squeezed with a knife. They possessed a bland oleaginous taste, but when chewed left a faint peculiar after-taste.

No. 2.—These seeds did not differ materially from those of sample No. 1 in appearance, but they were slightly darker in colour and had a somewhat mouldy odour.

The seeds were analysed and gave the following percentage results:—

	Sample 1. Per cent.	Sample 2. Per cent.
Moisture	5·8	5·8
Fat	46·6	46·6
Crude proteins	17·5	18·1
Consisting of—		
True proteins	11·3	10·2
Other nitrogenous substances ...	6·2	7·9
Soluble carbohydrates	*Nil.*	*Nil.*
Starch, &c.	11·8	12·1
Crude fibre	15·6	14·7
Ash	2·7	2·7

As the seeds contained so large a percentage of fat, it was considered advisable to submit this constituent to detailed investigation. It was a hard white crystalline fat, possessing a peculiar odour. The results of its examination were as follows:—

	Fat from Sample No. 1.	Fat from Sample No. 2.
Specific gravity at 15·5° C. ...	0·898	0·896
Acid value	4·5	22·4
Saponification value	192·4	193·9
Iodine value	99·7	96·8
Titer test	57·8° C.	57·8° C.
Hehner value	96·5	96·5
Reichert-Meissl value... ...	*Nil.*	*Nil.*
Unsaponifiable matter ...	1·6	1·3

The higher acid value of the fat from sample No. 2, and the variations of the other constants from those of No. 1, are probably due to the fact that the seeds of sample No. 2 were somewhat mouldy. The constants of the fat from sample No. 1 are therefore probably the more normal. The fat yielded a hard soap of satisfactory appearance but possessing the persistent odour of the fat itself. The fatty acids, of which the fat is composed, consist of a solid, crystalline acid (chaulmoogric acid), about 87·5 per cent., and unsaturated liquid acids, about 12·5 per cent. (For further particulars see a paper by Dr. E. Goulding and Mr. N. C. Akers, of the Imperial Institute, *Proc. Chem. Soc.*, 1913, **29**, 197.)

Chaulmoogric acid has been found to induce vomiting in certain animals, and it is therefore evident that neither the fat nor the cake left after expressing it could be employed safely as food. The fat might be of value, however, for soap or candle manufacture, but no definite opinion can be expressed on this point until technical trials have been made.

"TAI FUNG CHI YAU" OIL.

HONG KONG.

This oil, which is said to be produced in Kwangsi Province, was received for examination from Hong Kong in July, 1911. It was cloudy, yellowish-brown in colour, and became semi-solid on standing.

The results of chemical examination of the oil are shown in the following table:—

—	Present sample.	Oil of *Gynocardia odorata.*	"Lukrabo" oil from *Hydnocarpus anthelminticus.*
Specific gravity ...	0·956 at 15·5° C.	0·927 at 25° C.	0·952 at 25° C.
Acid value	37·6	—	—
Saponification value ...	192·0	199·6	208·0
Iodine value	86·5	152·0	82·5

According to information supplied by the Superintendent of the Botanical and Forestry Department in Hong Kong, this oil is said to be derived from *Gynocardia odorata*. The foregoing results, however, show that it does not resemble the oil of *G. odorata* (Power and Barrowcliff, *Trans. Chem. Soc.*, 1905, **87**, 898), but is more like that of *Hydnocarpus anthelminticus* ("Lukrabo" oil), which is known, according to Power and Barrowcliff, as "Ta fung tsze" (*Trans. Chem. Soc.*, 1905, **87**, 893). The present sample, moreover, is optically active, whereas *Gynocardia* oil is not. The oil under report thus appears to be derived from *Hydnocarpus anthelminticus*, or possibly some closely allied species. In the United Kingdom the oil would only be suitable for soap-making, and it is not worth consideration for this purpose unless large quantities are available cheaply. Hydnocarpus oils were recently imported to Europe, and unfortunately used for the preparation of edible fats, and gave rise to several cases of poisoning (see *Bulletin of the Imperial Institute*, 1911, **9**, 406).

MARGOSA SEED (*Melia Azadirachta*).

India.

A small consignment of Margosa seed was forwarded to the Imperial Institute by the Officiating Reporter on Economic Products in September, 1911. It was stated to have been collected in the Rae Bareli District of the United Provinces.

The consignment consisted of unshelled seeds, each composed of a thin woody shell and a single soft oily kernel. The seeds had undergone a considerable amount of fermentation during transit from India, and most of the kernels were mouldy on arrival, whilst a fair proportion were decomposed. The kernels were mostly very dark brown internally, and had the odour of garlic, which is characteristic of Margosa kernels.

The consignment was forwarded to a firm of soap-makers who had expressed a wish to carry out technical trials with Margosa seed. After making a detailed examination of the seed the firm furnished the following report.

The seeds consisted of shell, 55·3 per cent., and kernel, 44·7 per cent. The kernels were found to have the following percentage composition:—

Fat	48·90*
Moisture	5·12
Proteins	26·67
Carbohydrates	12·24
Ash	4·28
Woody fibre	2·79

With reference to the yield of fat, it may be stated that the Margosa kernels from Ceylon referred to below yielded 59·25 per cent. of fat, equivalent to a yield of nearly 31 per cent. on the whole seeds. The Ceylon kernels were, however, in much better condition than those from India.

The fat from the Indian seeds was of soft consistence. When extracted by a solvent from the kernels it was yellowish, but when obtained by crushing the entire seed it was dark reddish-brown. The fat obtained by the latter method was found to have the following constants:—

Saponification value		191·80
Free fatty acids, expressed as oleic acid	per cent.	42·68
Unsaponifiable matter		0·22
Glycerine	per cent.	5·64

The fatty acids were examined with the following results:—

Specific gravity	0·8578
Iodine value	63·81
Titer test	35·70° C.

The crude expressed fat furnished a soap of inferior brown colour.

The manufacturers stated that the smell of garlic given off by the seeds was almost intolerable when they were heated before being crushed, and would render it quite impossible to express the fat from these seeds on a large scale in any oil-mill situated in a town. They added that the oil on account of its odour would command only a relatively low price, unless the smell could be removed by treatment with superheated steam or otherwise.

Ceylon.

A supply of Margosa seed was forwarded to the Imperial Institute by the Secretary of the Ceylon Agricultural Society in February, 1911.

This consignment consisted of unshelled seeds, each composed of a thin woody shell and a single soft oily kernel. The seeds were in very good condition on arrival at the Imperial Institute and showed no signs of mouldiness or "heating." The kernels were yellow internally and had the odour of garlic, which is characteristic of Margosa kernels.

The consignment was forwarded to the firm who carried out the trials with the Indian seed referred to above. After making a detailed examination of the seed the firm furnished the following report.

* Equivalent to a yield of about 23·5 per cent. on the whole seeds.

The seeds consisted of shell, 54·2 per cent., and kernel, 45·8 per cent. The kernels were found to have the following percentage composition:—

Fat	59·25*
Moisture	4·65
Proteins	20·53
Carbohydrates	9·10
Ash	3·44
Woody fibre	3·03

The fat was of soft consistence. When extracted by a solvent from the kernels it was yellowish in colour, but when obtained by crushing the entire seed it was dark greenish-brown. The fat obtained by the latter method was found to have the following constants:—

Saponification value		193·90
Free fatty acids, expressed as oleic acid	per cent.	5·37
Unsaponifiable matter		0·34
Glycerine	per cent.	9·61

The fatty acids were examined with the following results:—

Specific gravity	0·8569
Iodine value	66·70
Titer test	40·80° C.

The crude expressed fat furnished a soap of inferior yellowish-brown colour. After refining, the fat was lighter in colour, and gave a fair, dull greenish-yellow soap. The colour of the fat and of the soap made from it are, however, very poor.

These Ceylon seeds, like those from India, also gave off an intolerable odour of garlic when heated as a preliminary to the expression of the fat.

Remarks.

It will be seen from the above results that the fat expressed from these Margosa seeds from India and Ceylon was of poor quality for soap-making purposes, chiefly on account of its dark colour and very unpleasant odour. A further examination of the fat was made at the Imperial Institute to ascertain whether the odour could be removed by any simple process, but without success. It seems unlikely, therefore, that a market can be found in Europe for Margosa seed.

* Equivalent to a yield of about 31 per cent. on the whole seeds.

VEGETABLE WAXES.

The most important vegetable wax of commerce is Carnauba wax, obtained from the leaves of a palm, *Copernicia cerifera*, Mart., indigenous to tropical South America. This wax is prepared by cutting the leaves before they are fully open, drying these in the sun and brushing or scraping off the wax. The latter is then thrown into boiling water and melted.

The carnauba wax of commerce is a hard, brittle, yellowish or brownish-grey substance, and is used in the manufacture of candles, polishing-pastes, paper varnishes, phonograph records, electric cable coverings, &c.

The wax is shipped from Ceara, Pernambuco, and other Brazilian ports, principally to Germany, the United Kingdom, and the United States.

The present market price of the wax is about 157 shillings per cwt. (May, 1913), but the price is liable to fluctuate, owing chiefly to the fact that production is restricted to the northern part of South America.

The value of any new or little known vegetable wax, such as those mentioned below, would depend largely on its suitability for use as a substitute for carnauba wax.

BERRY WAX.

CAPE PROVINCE.

A sample of this wax was supplied to the Imperial Institute, at the suggestion of the Director, by the Agent-General for Cape Colony, in order that it might be examined and its exact commercial value ascertained.

The sample consisted of a moulded cake of wax weighing 5½ lb. In its general characters the wax was similar to the material usually known as Myrtle wax, which is derived from *Myrica cerifera*. The Cape berry wax is probably derived from one or other of the several species of Myrica growing in South Africa, which include *M. quercifolia*, *M. cordifolia*, *M. laciniata*, and *M. serrata*.

The following table gives the constants of this wax as ascertained in the Scientific and Technical Department of the Imperial Institute, with the figures previously recorded for myrtle wax for comparison. It will be seen that the figures correspond very closely.

	Cape berry wax.	Myrtle wax.
Specific gravity at 99° C. ...	0·8741	0·875-0·878
Acid value	4·09	—
Saponification value ...	211·1	205-217
Iodine value	1·06	1·95-3·9
Mean molecular weight of fatty acids	236·1	243
Melting-point of wax ...	40·5° C.	40·8° C.
Melting-point of fatty acids	47·5° C.	47·5° C.

These results indicated that the wax might be found useful by soap-makers, and possibly for the manufacture of candles, although it appeared that the comparatively low melting-point of the fatty acids might render the material unsuitable for the latter purpose.

Samples of the wax were submitted to two firms of manufacturers for valuation. One of these reported that the wax was not suitable for candle-making, but that it yielded a hard white soap. They wished to have a few hundredweights for trial, and estimated its value at two-thirds to three-quarters the price of ordinary beef tallow, *i.e.*, from 22*s.* to 24*s.* a cwt. at that time (December, 1906).

The second firm, after inspecting the sample and having been informed of the results of its examination at the Imperial Institute, requested that a trial consignment of 10 tons of the wax might be obtained at a price not to exceed £29 per ton net c.i.f. Liverpool. It proved impossible, however, to obtain the quantity required for the trial consignment owing to the absence of any organisation for collecting the wax at the proper season. From information subsequently received there is no doubt that large quantities of the wax will be available, provided that the collection of the material is carried on continuously during the season, and since then consignments have been sold at intervals in London.

RAPHIA WAX.

MADAGASCAR.

In a communication made to the Paris Academy of Science in December, 1905, Professor M. H. Jumelle, of Marseilles, drew attention to a vegetable wax, prepared by the natives in certain districts of Madagascar, from the leaves of the raphia palm (*Raphia Ruffia*), well known as the source of the "bass" used by gardeners for attaching plants to stakes. A fuller account of the preparation of this material was given in the *Bulletin Economique de Madagascar* (1906, **6**, 48). As it appeared, from the first accounts published, that this product might be of some economic value, the Director of the Imperial Institute applied to H.M. Consul at Tamatave for samples of the wax, and these were supplied early in 1907. The wax has been examined, and submitted for technical trial to manufacturers.

Raphia bass consists of the epidermal portion of the upper side of the leaf of the raphia palm. When the leaf opens out the two surfaces which have been in contact in the young stage form the upper surface of the leaf. This has a glossy epidermis which, on being stripped off, forms the bass. It is on the dull under surface of the leaf that the wax occurs as a whitish layer or bloom, readily detachable by rubbing lightly with the finger.

It is from the residues of the leaves left after the extraction of the bass, that the wax has, up to the present, been obtained. These residues, called by the natives "Taimbontgona," are available in large quantities in the neighbourhood of the raphia groves which have been worked for bass. They are spread o

to dry on cloths in the open air, sheltered from the wind, as even a slight breeze is sufficient to blow away much of the light waxy matter. The drying usually takes from two to four days, and at the end of that time a white pellicle is apparent on the under surfaces of the leaves. It is then only necessary to shake the leaves or to rub them between the hands to cause the waxy matter to detach itself, mostly in the form of powder or fine dust. The powder is collected, sifted from foreign material, and placed in boiling water, when the wax melts and floats to the surface, whilst any earthy impurity settles to the bottom. The liquefied wax is then transferred to a receiver, where it is allowed to cool and solidify. The product thus prepared is yellow to dark brown in colour, rather harder and more brittle than beeswax.

The following quantities are given as the yields of bass and wax in an experimental extraction of these products in Madagascar. The experiment was made on ten raphia palm leaves of medium size ($3\frac{1}{2}$ to $4\frac{1}{2}$ metres in length).

	Kilos.
Total weight of leaves	104·5
Weight of dry bass obtained	4·6
Weight of dry residues (less the ribs of leaves)	11·0
Weight of wax after preparation	0·78

In this experiment the yield of wax was equal to 0·75 per cent. of the weight of leaves used, and to about 17 per cent. of the weight of dry fibre extracted. In practice, however, it would be lower, and possibly equal to about 10 per cent. of the weight of fibre.

Professor Jumelle showed that in many respects this product resembles the carnauba wax of commerce, obtained from *Copernicia cerifera*. It has approximately the same melting-point (83° C.), and behaves in the same way towards various solvents. Raphia wax has been subjected to a more detailed examination by Professor Haller and M. Descude. The results of these investigations indicate that although in physical properties raphia wax resembles carnauba wax to some extent, the two differ considerably in composition.

Two samples of the raphia wax were received at the Imperial Institute. The first consisted of a solid cake weighing 330 grams.

It was yellowish-brown in colour for the most part, but greyish at the edges, and was sufficiently brittle to powder in a mortar.

The second sample was larger, and consisted of two cakes weighing together eight pounds. The lower part of one of these cakes contained a large quantity of sandy or gritty impurity due to careless preparation. Only the upper portion of this was taken for chemical examination.

The results are given in the following table, which also includes, for the purpose of comparison, the corresponding values for carnauba wax and beeswax.

—	Raphia wax. 1	Raphia wax. 2	Carnauba wax.	Beeswax.
Specific gravity at $\frac{99° \text{C.}}{15 \cdot 5° \text{C.}}$	0·836	0·832	0·842	0·820
Acid value	4·9	6·5	3·4–7·0	19–21
Saponification value ...	51·3	50·3	79–84	90–99
Iodine value...	7·68	10·7	13·5	8–11
Melting-point of wax ...	82° C.	83° C.	83°–86° C.	63°–65° C.

Results of Technical Trials.

The results of the comparative examination showed that the raphia wax agreed closely in physical characters with carnauba wax, and it was considered likely that it might be used for the same purposes, such as the manufacture of polishes, candles, &c.

A firm of boot-polish manufacturers, who were consulted on this point, were at first inclined to view the product favourably, and asked for a larger sample for trial. Unfortunately the second large sample received at the Imperial Institute, as indicated above, contained a good deal of gritty impurity, and this the manufacturers reported rendered the material unsuitable for their purpose.

A firm of candle and soap manufacturers who were also consulted, reported that in some respects the material possessed the qualities of certain waxes already on the market, and although they took exception to the inherent "oiliness" and the dark colour of the wax, they expressed their willingness to purchase a small consignment at the rate of £40 per ton, for trial on a large scale. Enquiries made by H.M. Consul at Tamatave as to the possibility of obtaining commercial supplies of the wax, indicate that a price of £40 per ton would not cover the cost of collecting, preparing, and shipping the wax, and that the latter cannot be produced at present for less than £80 per metric ton f.o.b. Tamatave (Feb. 1908).

ANIMAL OILS.

FISH OILS.

These oils are obtained from the bodies of many kinds of fish such as herrings, sardines, etc.; the bodies of fish yielding liver oils, *e.g.*, cod, do not as a rule contain any appreciable amount of oil.

Fish oils are prepared either from whole fish or from the refuse from canneries and curing factories, by boiling and pressing the fish or sometimes by extraction with solvents from dry fish.

The fish oils resemble the vegetable oils in consisting almost entirely of glycerides but frequently contain clupanodonic acid which has not been detected in vegetable oils; they usually have a high iodine value.

All fish oils are liable to be dark coloured and malodorous owing principally to the rapidity with which the fish deteriorates before the preparation of the oil, but since the advent of rapid transit in steam trawlers and also owing to improved methods of preparation fish oils can now be obtained of paler colour and less offensive smell. Many attempts have been made to remove the fishy smell and so render the oils fit for edible use but so far without success although it seems possible that the recently introduced process of hardening glycerides by hydrogenation in presence of catalysts (nickel, etc.) may effect this.

The residue remaining after the removal of the oil finds a ready market as a manure under the name of fish guano and the best grades are also used to some extent for cattle feeding.

Fish oils are chiefly used in leather dressing and also in the manufacture of cheap paints, in soap-making and for the adulteration of cod liver and other oils. One of the most important fish oils is "menhaden oil" which is prepared in large quantities on the Atlantic coast of North America.

INDIA.

The preparation of sardine oil forms an important part of the experimental work of the Madras Government Fishery Department. Hitherto such work has been carried on at the Cannanore Experimental Station, but during 1911-12 it was transferred to the Experimental Station at Tanur, where fish are usually more abundant. At first crude brown oil only was prepared, but as there is a better market for the finer grades of fish oil new machinery has been installed at Tanur for producing pale coloured oil, for separating the stearin and for refining the oil, whilst deodorising experiments are also to be conducted there. The efforts of the Department to create a local fish oil industry have been highly successful; in 1909 there was only one private factory, whilst at the beginning of the 1911-12 season between forty and fifty small factories were producing crude brown oil in Malabar and South Canara, and the erection of factories in Cochin and Travancore is probable.

Seven samples of sardine oil and one sample of "stearin" obtained from sardine oil were received from the Madras Government Fisheries in August, 1912. They were as follows:—

1. "Palest oil from Cannanore."—A pale yellow oil, which deposited stearin on standing.

2. "Palest oil without stearin."—This was a bright yellow oil, clear when received at the Imperial Institute, but like the other samples designated "oils without stearin" (Nos. 4 and 6) it deposited stearin to some extent at the temperatures commonly prevailing in Europe, viz., up to 20° C.

3. "Palest oil with stearin."—A yellow oil with a deposit of stearin.

4. "Yellow oil without stearin."—A pale brown oil.

5. "Yellow oil with stearin."—A pale brown viscous oil.

6. "Brown oil without stearin."—Thick brown oil, possessing an unpleasant odour.

7. "Brown oil with stearin."—Dark brown semi-solid oil, possessing an unpleasant odour.

8. "Stearin."—Pale brown, soft fat.

The samples were examined with the results shown in the following table; No. 7 contained about 3·2 per cent. of water which was removed before the constants were determined.

—	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
Specific gravity at 100°/15° C.	0·878	0·877	0·877	0·877	0·876	0·876	0·875	0·874
Acid value	3·7	2·3	1·8	4·7	7·1	35·0	53·5	9·0
Saponification value...	196	194	194	193	198	199	200	198
Iodine value	154	156	157	159	154	157	157	131

The general characters and constants of these sardine oils indicate their suitability for the usual purposes to which fish oils are applied, viz. leather-dressing and currying, and to a smaller extent for soft soap manufacture, tempering steel, admixture with paint-oils, and jute-batching. The stearin would also be suitable for use in leather manufacture and soap-making.

The various fish oils used in commerce (*e.g.* cod, herring, menhaden, Japanese sardine and shark liver oils) differ a good deal from one another in physical and chemical characteristics, but they all have a high iodine value. This constant is of great importance, as it indicates the readiness with which an oil will undergo oxidation, a property on which the value of an oil for leather-dressing largely depends.

The principal fish oil used in the leather industry of the United Kingdom is cod oil, commercial specimens of which usually have an iodine value of about 155. It will be noticed that the iodine values of these sardine oils from Madras (viz., 154 to 159) approximate very closely to this figure.

With the exception of the brown oils (Nos. 6 and 7), all the samples furnished low acid values and appeared to have been carefully prepared. The somewhat high acid values of the brown oils would reduce their value for leather-dressing, as such oils are usually regarded as unsatisfactory for this purpose.

ANIMAL FATS.

"GHI" FROM INDIA.

The most important animal fat is butter, which consists principally of the fat of cow's milk. In India the fat is freed from water and curd by heating and is then known as "Ghi." The following samples of "ghi" were examined in connection with an investigation into the possibility of manufacturing a substitute for "ghi" from Indian cotton-seed oil (see p. 462).

Most of the "ghi," produced in India is consumed locally but there is a considerable export to the Straits Settlements, Natal, Ceylon and other countries. The total exports of "ghi" from India in recent years are shown in the following table:—

—	1907-8.	1908-9.	1909-10.	1910-11.
	Tons.	Tons.	Tons.	Tons.
Quantity	2,204	2,150	2,206	2,359
	£	£	£	£
Value...	178,248	161,616	165,543	186,280

Three samples of "ghi," two made from buffalo's and one from cow's milk, were forwarded to the Imperial Institute by the Director-General of Commercial Intelligence in September, 1908. Two of the samples were specially prepared and were stated to be pure "ghi." The third sample, made from buffalo's milk, was said to be representative of the ordinary "ghi" of good quality sold locally.

Description of samples.

No. 1. Labelled "Pure cow's milk 'ghi' at Rs.1-14-0 a seer."
The sample consisted of soft, buff-coloured, solid fat. The portion near the mouth of the bottle had a slight cheese-like odour, the remainder had a strong but not unpleasant smell suggesting that the fat had been over-heated during preparation.

No. 2. Labelled "Pure buffalo's milk 'ghi' at Rs.1-8-0 a seer."
The sample consisted of nearly white fat, softer than No. 1 and having a rather mouldy smell, but otherwise resembling No. 1 in odour.

No. 3. Labelled "Ordinary buffalo milk 'ghi'."
The sample consisted of "ghi," intermediate in colour between Nos. 1 and 2 and of about the same consistence as No. 1. The smell was similar to that of No. 1 but not so marked.

Results of Examination.

The fats contained the following amounts of moisture and curd:—

—	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	2·0	0·4	0·5
Curd	0·35	0·0	0·0

The fats freed from moisture and curd were found to have the following constants:—

—	No. 1. Pure cow's milk "ghi."	No. 2. Pure buffalo's milk "ghi."	No. 3. Ordinary buffalo's milk "ghi."
Specific gravity at 100°C./15·5°C.	0·864	0·866	0·864
Acid value...	7·24	5·46	11·1
Saponification value	222	226	224
Iodine value	34·8	34·6	35·0
Titer test of the fat (not the acids)	30·2° C.	29·4° C.	26·1° C.
Reichert-Meissl value	24	31	29

The above results show that there is very little difference between the chemical characters of cow's milk "ghi" and those of "ghi" prepared from buffalo's milk. The samples were all slightly rancid, as the high acid values show. No. 3 was the most rancid. The Reichert-Meissl values of the two samples of buffalo's milk "ghi" are higher than that of the cow's milk "ghi," but they are still within the limit usually allowed for the fat of ordinary cow's milk butter.

ANIMAL WAXES.

BEESWAX.

Beeswax consists of the comb of the common bee (*Apis mellifica*) and other species. It is produced throughout the temperate and tropical regions of the world by wild or domesticated bees and there are large exports from the West Indies, various parts of Africa, South America and elsewhere.

It consists chiefly of "cerotic acid," a mixture of homologous acids, and myricin, a compound of melissyl alcohol and palmitic acid; free melissic acid, myricyl alcohol, ceryl alcohol, hydrocarbons and other constituents are also present in small quantities.

Beeswax is chiefly used in the manufacture of candles and for the preparation of various kinds of polishes.

The Imperial Institute has examined a considerable number of samples of beeswax, principally from British dependencies in Africa, and in addition has supplied a number of memoranda on the preparation and production of beeswax. The whole of this work up to the end of 1909 was summarised in the *Bulletin of the Imperial Institute* (1910, **8**, 24), and that account has been brought up to date and reproduced below, together with summaries of the reports on samples of beeswax made since that date.

PREPARATION OF BEESWAX.

Modern methods of bee-culture, as adopted in most European countries, Australia, the United States of North America and elsewhere, have for their primary object the production of honey, since the latter realises a better price than wax. In former times when bees were kept in "skeps" or boxes a large number of swarms were destroyed annually, and the whole of the comb, after the honey had been extracted, was converted into wax. As one result of the use of movable box hives it is no longer necessary to destroy all the comb, but merely to remove the cell-capping and extract the honey by means of a machine. The empty comb can then be returned to the hive and re-filled. As bees consume a large quantity of honey in order to make wax, the modern bee-keeper effects a considerable saving in this respect by using the same comb several times. This practice, however, withholds a considerable quantity of wax from the market. The modern custom of retailing honey in the comb, owing to the ease with which extracted honey can be adulterated, likewise prevents a quantity of wax from finding its way to the market as such.

In consequence of the inability of European and other countries where modern methods of bee-culture are practised, to meet the increasing demands of manufacturers for this product, the markets have come to depend more and more for their supplies on countries where the wax produced by wild bees is collected and exported. This industry is at the present time attracting a considerable amount of attention, especially in Eastern, Central, and Western Africa, and for that reason it is

of interest to give some account of the methods adopted in preparing beeswax for the market.

Wild wax seldom equals the cultivated product in quality, and this is frequently due to careless methods of preparing it for export, and to adulteration. By paying more attention to the few simple details connected with the process of preparing beeswax for export, it would be possible to produce wax from wild bees almost equal in quality to the European article and which would command a similar price on the market.

There are several methods of "rendering" wax, as the process of separating wax from honey and impurities is termed, and in some countries special appliances are in use for this purpose. In many cases, however, these appliances are too delicate or too complicated in structure for native use and in such countries one or other of the following simple methods is recommended.

The melting of beeswax can be effected either by using sun heat, direct fire heat, boiling water or steam. In a melted state beeswax readily separates from such foreign substances as may be contained in it, and owing to its lower specific gravity will float on the surface of the water.

A simple method of rendering wax, and one formerly adopted by bee-keepers in this country and elsewhere, is to extract as much honey as possible from the comb, first by draining and then by pressure in a press of the ordinary copying-press type, and finally by melting it in presence of water, which dissolves out any residual honey which may cling to the pressed wax. While melted, the wax is strained through calico to remove solid impurities, and is finally re-melted over a fire to remove water, after which it is poured into moulds to set. Care is required in carrying out the final melting as burning may occur, and when this happens a dark-coloured wax of low market value is produced.

Another method followed by bee-keepers who have not adopted modern appliances is to place the comb, after the honey has been extracted, in a canvas bag, which is kept below the surface of the water, contained in a copper or other large vessel, by being weighed with stones. If the comb contains "brood" it is allowed to soak in water for twenty-four hours before being placed in the copper, the object being to fill the dry cocoons with water, which will prevent them absorbing the melted wax. The water in the copper is next heated, and as the wax melts it passes through the canvas bag and rises to the surface of the water, leaving behind in the bag all solid impurities. The bag is taken out of the copper and squeezed between two pieces of wood to extract as much wax as possible, and the surface of the melted wax in the copper is frequently skimmed to remove scum and other impurities. A cloth is then thrown over the vessel, and the wax and water allowed to cool as slowly as possible. The wax solidifies into a cake which can easily be removed from the water. On the under side of the cake there is usually a discoloured layer containing impurities, and this is scraped off and worked up with the next batch of crude wax

The remainder is broken up into small pieces, re-melted and poured into moulds to set. Provided that care is taken (1) not to boil the water too fast or for too long a time, and (2) to prevent burning during the final melting, this method produces clean wax of good colour; but if either of these precautions be neglected it becomes dry and brittle, and of a brownish hue. The outfit required for the foregoing operations is simple and obtainable almost everywhere.

Of the modern appliances for rendering wax one of the simplest is the "Solar wax extractor," which is in common use in the United States, Australia, and elsewhere. This consists of a wooden box with a sloping double glazed lid. Inside the box, and raised some distance from its floor, an inclined tin tray is fixed. The comb is placed on the tray, the lid tightly closed, and the box exposed to the sun. The temperature inside the box rapidly rises, and when it reaches about 147° F. the wax melts and runs off the sloping tray into a vessel beneath, leaving impurities behind, caught by a wire gauze strainer. This appliance is admirably suited to warm countries, and wax obtained by its use is of good quality, and requires no further refining. It is, however, not suitable for rendering comb containing brood or other gross impurities. In treating comb of this description it is best to extract the wax by one of the methods mentioned above, and then to clarify it by means of the "Solar extractor." Most of the other appliances are provided with a screw press by means of which the wax is forced through strainers after being melted by means of hot water or steam.

Production of Beeswax in Africa.

There is at the present time a considerable export of beeswax from various parts of Africa, and in view of the vast extent of forest land in Africa well stocked with wild bees, this trade is capable of expansion. A race of the common hive bee of Europe known as *Apis mellifica*, Linn. var. *Adansonii*, Latr., occurs throughout the African continent from Egypt to West Africa, and southwards to the Cape, but with the exception of the Fellaheen of Egypt, few, if any, of the African peoples have domesticated bees.

A number of samples of beeswax have been received at the Imperial Institute from British Colonies and Dependencies in Africa, and as illustrating the generally excellent quality of the material obtainable, the following tabular statement of the results of their examination and valuation may be given (p. 589).

From several of these countries beeswax is exported already, and in all of them bees are stated to be abundant, so that there is room for the development of this industry. It is scarcely worth while to refer in detail to the production of wax in each of these and other African Territories in which this industry is carried on, or is susceptible of development, and in the following pages reference is only made to a few countries in which developments have recently occurred, or in which the industry is specially well organised.

County of Origin.	Specific gravity at 99°/15° C.	Melting-point.	Saponification value.	Acid value.	Ester value.	Moisture.	Ash.	Matter soluble in water.	Matter insoluble in chloroform.	Valuation.	Date of valuation.
		°C.				Per cent.	Per cent.	Per cent.	Per cent.	Per cwt. £ s. d.	
Nyasaland Protectorate.	—	—	—	—	—	—	—	—	—	6 17 6 to 7 0 0	Feb. 1904
Imported to Sudan from Abyssinia.	—	—	—	—	—	—	—	—	—	6 0 0	Oct. 1905
Bahr-el-Ghazal, Sudan.	—	—	—	—	—	—	—	—	—	7 0 0	Mar. 1906
Sudan	0·821	66°	84·6	20·6	64·0	1·35	0·42	1·20	0·60	—	—
Southern Rhodesia	—	—	—	—	—	—	—	—	—	6 12 6 to 6 15 0	Oct. 1907
Gold Coast Colony	0·829	64·5°	90·8	20·5	70·3	*Nil*	0·16	0·28	1·10	6 15 0	Dec. 1908
Uganda Protectorate.	0·812	63·2°	92·4	18·6	73·8	0·6	0·08	—	—	6 12 6	Jan. 1909
Commercial beeswax.	0·822	63°–64°	90 to 95	19 to 20	71 to 75	—	—	—	—	6 5 0 to 7 0 0	Feb. 1909

German East Africa.

During recent years much attention has been devoted to the subject of beeswax production in German East Africa, and as a result beeswax now ranks high as an article of export from that Protectorate (*Bulletin of the Imperial Institute*, 1910, **8**, 56). In 1909, 199 tons, valued at £23,165, were exported and in 1910, 195 tons, valued at £22,450. It has been observed that wild bees are attracted in large numbers by the flowers of the Ceará rubber tree (*Manihot Glaziovii*) and other cultivated crops. In German East Africa swarms of bees are encouraged to settle, by placing in favourable situations on the plantations, rough hives, consisting of hollow branches or tree trunks, boxes, or cleansed kerosene tins. A piece of honeycomb placed in these receptacles soon attracts a swarm, and when once the bees can be induced to settle they increase rapidly. These rough hives are quickly filled with honeycomb, which is removed at night in the ordinary way, care being taken to leave sufficient honey in the hive to encourage the bees to start building again. The comb containing brood is not taken, and special precautions are observed to prevent the natives from stealing the brood-comb, as they like to eat young bees. To "render" the wax, a modification of a process already described is adopted. The comb containing the honey is broken up, and thrown into a large vessel and carefully melted at a low temperature. The wax separates from the honey, and when both have cooled, the former rests on the latter as a solid cake. This cake is removed the under surface, which contains impurities, is scraped off, and the remainder broken up into small pieces and melted in the presence of several times its bulk of water. Whilst in a melted state the wax is filtered through a piece of cloth and finally run into moulds. Any vessel may serve as a mould, provided its shape is such that the solid cake of wax can be easily removed.

The honey obtained from the flower of the Ceara rubber tree is unsuitable for food, but is fed to the bees. These eat it greedily, and use it for the production of wax, with which t

replenish their hives with comb. It is estimated that a strong swarm of bees will produce from 7 to 11 lb. of wax in a year, and as the cost of collecting and preparing it for export is small there is a good return for the labour and expenditure involved.

Uganda Protectorate.

Quite recently the Agricultural Department of Uganda has taken up the subject of beeswax production in that Protectorate, and two Baganda chiefs have been sent to German East Africa to study the methods followed there, and described above, in the preparation of wax for export. On the return of these chiefs to Uganda, leaflets in English and Luganda setting forth the advantages to be derived from bee-keeping and giving instructions as to the methods of procedure for obtaining wax of good quality, were widely circulated. The men who visited German East Africa were, on their return, sent to various parts of Uganda to give demonstrations to natives in the preparation of wax, and as a result some thousands of hives have been erected and many are occupied. There is reason to believe that in the near future beeswax will form one of the staple exports of Uganda. In 1910-11, 35 cwts., valued at £162, were exported, and in 1911-12, 32 cwts., also valued at £162.

In the supplement to the *Uganda Gazette* for May 15, 1909, Mr. Dawe, of the Uganda Botanical, Scientific and Forestry Department, recommends the use of the old system of skep hives for wild bees. This system is already used by some missionaries in the Protectorate with good results. Native-made baskets inverted and plastered with cow-dung and mud serve as hives, and when the bees swarm a second hive is placed on the top of the first, a small hole in the top of the first hive providing the means of communication between the two. When filled with honeycomb the top hive can easily be removed, and as only the worker bees can pass from the lower hive through the small hole into the upper, no brood comb is formed in the latter.

A leaflet in Luganda describing the skep hive is being published for distribution, and as soon as the advantages of the skep over more primitive hives are recognised, its adoption will, no doubt, become general throughout the country.

East Africa Protectorate.

In this Protectorate the subject of beeswax production for export is also receiving attention, and one of the Baganda chiefs (see above) who visited German East Africa has been loaned to the authorities for the purpose of instructing the natives in the methods to be followed. Considerable quantities have been produced in recent years, as is shown in the following table:—

—	1908-9.	1909-10.	1910-11.
	Tons.	*Tons.*	*Tons.*
Quantity	266	115	195
	£	£	£
Value	29,656	12,987	22,330

Gambia.

Already a large quantity of beeswax is annually exported from the Gambia, the exports for 1910-11 being 230 cwts., valued at £1,274, and 302 cwts., valued at £1,514, respectively. This is collected in the Kommbo and Fogni districts, where there are vast areas of forest land well stocked with bees. The natives collect the wax and sell it in a crude state to European merchants, who clarify it before it is exported. According to a report supplied by the Governor of the Gambia to the Imperial Institute recently, the process of clarification used is as follows: A special building known as the wax-house is provided, and in this is arranged a row of large cooking-pots with a fire-place beneath them. Fixed to the wall near the pots is a screw-press of the ordinary copying-press pattern, but with a box-like receptacle to hold the melted wax. The pots in which the wax is to be melted are half filled with water and the fires lighted. Into these pots the crude wax is thrown after being broken up into small pieces. The water is allowed to boil for about three hours, and the melted wax is then ready for the press. The press receptacle into which the wax is poured measures 21 × 26 × 26 inches, and has a lining of perforated zinc fixed at about half-an-inch from the sides. Space is thus provided for the escape of the wax and water when pressure is applied. A tube leads from the press and conducts the mixture of wax and water to a barrel placed to receive it. By means of a tap at the base of the barrel the water is drawn off from time to time, so that eventually little besides wax remains.

When using the press a layer of grass is placed at the bottom of the receptacle, and this is scalded with boiling water to prevent the wax adhering to it. A second layer of grass is arranged crossways on the first and then a layer of hot water and melted wax is poured over it from the cooking pots. Alternate layers of grass and wax succeed this until the receptacle is full, when pressure is applied by means of the screw. Under pressure the wax is squeezed out and escapes into the barrel, leaving all impurities between the layers of grass. The melted wax is allowed to remain in the barrel for from fourteen to fifteen hours, when it is sufficiently cool to handle, and is poured into moulds previously oiled to receive it.

Production of Beeswax in India.

The beeswax exported from India is the product of three species of *Apis*, namely *A. dorsata*, Fabr.; *A. indica*, Fabr.; and *A. florea*, Fabr. The wax derived from each of these is practically identical in composition, but differs somewhat from European wax, chiefly in its lower acid value. The collection of wax is carried on here and there throughout India and Burma, mainly by jungle tribes, who gather it from trees and rocks. Besides entering into a number of local industries, there is a considerable amount of beeswax exported mainly to Germany, the United Kingdom, France, Belgium and the Straits Settlements. In preparing the wax the honey is first removed by

squeezing the comb between the hands. It is then washed in cold water to further remove honey or other soluble matter contained in it, after which it is placed in a vessel half filled with water and heated over a fire. As a rule no attempt is made to grade the wax before melting, so that comb containing brood, eggs, twigs, leaves, grass, etc., is included in the boiling. These impurities separate from the wax when in a melted condition, and are removed by straining the wax through cotton cloth. On cooling, the wax is made into cakes, or balls. A second melting is sometimes given, and turmeric powder is frequently mixed with the wax to give it a bright yellow colour. In a melted state it is poured into vessels containing a little water, which serve as moulds.

The following table shows the total exports of beeswax from India in recent years:—

—	1908-9.	1909-10.	1910-11.	1911-12.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Quantity	236	351	428	629
	£	£	£	£
Value	26,406	39,278	49,240	66,159

The following further samples of beeswax have been reported on by the Imperial Institute since 1909:—

NORTHERN NIGERIA.

The seven samples of beeswax which are the subject of this report were forwarded to the Imperial Institute in September, 1910. They were stated to have been obtained from the Lapai and Zungeru districts of the Niger Province.

(1) Weight, 1½ oz. Small pieces of pale, partially bleached wax, free from obvious impurities.

(2) Weight, 8 oz. A thin circular cake of pale yellowish-brown wax, showing a few specks of dirt on the under-surface.

(3) Weight, 10 oz. A thin circular cake of pale yellow wax, which had apparently been partially bleached.

(4) Weight, 1 lb. Two thin rectangular cakes of pale yellowish-brown wax, clean on one surface but somewhat dirty on the other.

(5) Weight, 3½ lb. Six circular cakes of dark brown wax, somewhat dirty externally but clean within. The material had a "burnt" odour, probably due to over-heating during preparation.

(6) Weight, 4¾ oz. A circular cake of clean brownish-yellow wax, flat on one side and convex on the other, which had apparently been scraped to remove dirt.

(7) Weight, 4 oz. A flat rectangular cake of brownish-yellow wax, showing some dark brownish spots. The centre of the mass was soft and granular.

The following tables show (I.) the amount of impurities in the samples of wax as received, and (II.) the results of the detailed examination of refined wax prepared from the samples at the

Imperial Institute, to which the corresponding figures recorded for other samples of African beeswax are added for comparison:—

—Impurities in Samples of Wax as received.

	(1) *Per cent.*	(2) *Per cent.*	(3) *Per cent.*	(4) *Per cent.*	(5) *Per cent.*	(6) *Per cent.*	(7) *Per cent.*
Moisture ...	0·20	0·09	0·05	0·09	0·64	0·82	1·05
Dirt ...	0·11	0·18	0·05	0·18	0·20	0·33	0·21
Matter soluble in hot water	0·19	0·13	0·05	0·20	0·20	0·10	0·15
Ash ...	—*	0·03	nil	0·02	0·12	0·02	0·01

* *This sample was too small for this determination.*

II.—*Results of Chemical Examination.*

	Refined wax prepared from Northern Nigeria Samples.							Samples previously examined at the Imperial Institute.		Samples examined by:— Dietz	Berg	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	From Gold Coast.	From Uganda.	From Angola.	From German East Africa.	From Sierra Leone.
Melting-point	64·5° to 65°C.	63·5° to 64°C.	63°C.	63·5° to 64°C.	63·5° to 64°C.	63·5°C	61°C.	64·5°C.	63·2°C.	63·5°C.	63·9° to 64·5°C.	64°C.
Acid value ...	—	15·8	19·7	18·7	20·0	15·6	16·3	20·5	18·6	19·6	19·4 to 21·5	21·8
Ester value ...	—	78·0	76·3	76·6	75·3	78·4	77·2	70·3	73·8	73·0	80·7 to 80·9	80·1
Ratio of ester value to acid value.	—	4·9	3·9	4·1	3·7	5·0	4·7	3·45	3·96	3·7	3·75 to 4·16	3·76
Iodine value ..	—	9·3	5·9	5·9	7·5	9·5	8·1	—	—	—	—	—
Weinwurm's test.	Clear	Cloudy	Cloudy	Clear	Clear	Cloudy	Cloudy	—	Clear	—	—	—

It will be seen from Table I. that the samples contained only small amounts of moisture, ash, dirt, and "matter soluble in hot water" (probably a little honey), and they may therefore be regarded as carefully prepared.

The results of the chemical examination, as given in Table II., show that some of these samples of beeswax are slightly abnormal. Nos. 2, 6 and 7 have rather high ester values and somewhat low acid values, and consequently the "ratio" values are higher than the average recorded for pure beeswax, viz., about 3·7 to 4·2. Analyses of genuine beeswax have, however, been published, giving figures widely divergent from those which may be taken as the average, and it is therefore possible that these samples are

uncontaminated wax of somewhat different character from the African waxes previously examined. The analytical figures obtained for samples 3, 4 and 5 agree with those recorded for genuine beeswax.

Samples 2, 5, 6 and 7 yield a cloudy solution with Weinwurm's test. This test was originally designed to detect the presence of paraffin wax or other adulterants in beeswax, but it is well known that certain pure beeswaxes respond to the test owing to some slight abnormality in their composition. It is quite possible that the production of a cloudy solution in the present case may be due to a similar abnormality, but probably this would not interfere in any way with the technical application of the material.

The samples, with the exception of No. 1, were submitted to commercial experts, who described and valued them as follows:—

Sample.	*Description.*	*Value per cwt.*
2.	Clean, palish, re-melted ...	£6 17*s*. 6*d*.
3.	Clean, bleached, pale yellow ...	£7 5*s*. to £7 10*s*
4.	Clean, fair colour, remelted ...	£6 17*s*. 6*d*.
5.	Crude, darkish to fair colour, clean	£6 15*s*.
6.	Clean, palish, re-melted ...	£6 17*s*. 6*d*.
7.	Clean, pale, re-melted ...	£7

On the date of valuation, Jamaica beeswax was quoted in London at £7 5*s*. to £8 2*s*. 6*d*. per cwt., and East African at £6 5*s*. to £6 10*s*. per cwt. (March, 1911). The experts stated that the present demand for beeswax in London is good, and they anticipated that prices will be maintained.

It is understood that large quantities of beeswax are available in Northern Nigeria, and in some cases, *e.g.*, in the Zungeru and Lapai districts, rail transport is already available. In view, therefore, of the good prices which the material would realise in London, and the large demand which exists for beeswax in the United Kingdom, efforts should be made to establish an export trade in the product from the Protectorate.

Sudan.

The following samples were received from the Sudan in 1911 and 1912:—

No. 1.—"Beeswax from Sennar Province." This consisted of a number of circular cakes, flat on the top and rounded on the bottom surface. The upper portions of the cakes were in most cases clean, and of yellowish-brown colour, but the lower portions were dirty, dark greyish-brown, owing to the settling out of dirt as the wax cooled after melting. The wax could be improved in appearance by re-melting and straining.

An average sample of the wax was found to contain 0·66 per cent. of dirt (matter insoluble in carbon tetrachloride) and 0·24 per cent. of ash. The amount of ash in the wax was normal, but the percentage of dirt was too high.

A sample of the wax was submitted for valuation to commercial experts, who stated that the material was dirty, and in this state might not realise more than £6 7*s*. 6*d*. per cwt., but if fairly clean its value would be £6 15*s*. to £6 17*s*. 6*d*. per cwt. ex warehouse, London (September, 1911).

No. 2.—"Beeswax from the Yei River district." This sample consisted of a ball of wax, somewhat dirty on the outside, pale coloured, opaque, mottled, and free from obvious impurities.

The wax was submitted for valuation to brokers, who stated that the sample was very clean for rough ball, and worth fully £6 12s. 6d. per cwt., less $2\frac{1}{2}$ per cent. discount, ex warehouse, London (December, 1911). They added that beeswax of this description is easily saleable.

No. 3.—"Beeswax collected near Raga, in the Western District of the Bahr-el-Ghazal Province." This was a portion of a circular cake of pale-coloured wax, about $1\frac{1}{4}$ in. in thickness, and free from any appreciable amount of dirt except on the exterior. It was of a paler tint than the sample from the Yei River district, and was equally clean.

The wax was submitted to brokers, who valued it at [illegible] cwt., less $2\frac{1}{2}$ per cent. discount, ex warehouse, London (June, 1912). Consignments of similar wax would be readily saleable.

No. 4.—"Beeswax collected in the Yambio district of the Bahr-el-Ghazal Province." Four samples of this product were submitted as follows:

"*A.*—'Light' or 'clear' as brought in." Irregular lumps of pale brown, unmelted wax containing much honey.

"*B.*—'A' after being boiled down to about $\frac{1}{4}$ of its original weight." Irregular fragments of yellow wax, about $\frac{3}{16}$ in. thick, covered with mould externally, but clean within.

"*C.*—'Dark' or 'dirty' as brought in." Irregular lumps of dirty, dark brown wax.

"*D.*—'C' after being boiled down to about $\frac{1}{4}$ of its original weight." Irregular lumps of yellow wax, fairly clean inside, but containing some dirt.

The specimens were examined with the following results:—

—	A.	B.	C.	D.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	13·4	0·18	18·9	0·3
Dirt (approx.)	9·5	0·34	12·5	1·3
Water-soluble impurities, *i.e.*, honey, etc. (approx.).	38·0	0·27	49·5	0·7
Wax (approx.) by difference	39·1	99·2	19·1	97·7

The materials represented by samples A and C could not be offered as beeswax in the United Kingdom. It might be possible to sell such products as raw material for the extraction of wax, but it would be very much better to export clean wax prepared as already described (p. 586).

Beeswax represented by samples B and D would be saleable in the United Kingdom, the former being worth about £6 12s. 6d. and the latter about £6 10s. per cwt., less $2\frac{1}{2}$ per cent. discount (October, 1912). Slightly higher prices would be obtainable for the wax if it were shipped quite clean in the form of cakes.